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**AUGUST**
**1948**
**1/6**

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# DISCOVERY

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# The Progress of Science

## Britain's Second Atomic Pile

THE Gleep, Britain's first atomic pile, which has now been operating for a year, is capable of only a low power output and its usefulness is thereby limited. A new pile, rated at 6000 kilowatts, began operating at Harwell last month. Known as BEPO,* it ranks as a pile of intermediate power and is intended both for the production of large quantities of radioactive tracer isotopes, and also for physical research and the study of materials which will be used in the construction of still more powerful piles in the future.

The new pile is air-cooled, and graphite is the moderator used. It is constructed of several hundred tons of graphite blocks, in which a large number of cylindrical rods of uranium metal are arranged in a regular lattice. The uranium rods are enclosed in aluminium cans to protect them from corrosion and the canned rods lie in channels in the graphite. Cooling air is drawn through the channels and discharged up a 200-ft. chimney.

When the nuclear chain reaction is proceeding in a pile, the energy of $\beta$- and $\gamma$-radiation and of fission particles is rapidly degraded to heat. With the new pile running at full power, this heat will be produced at about a tenth of the rate at which a small power station works. At the present stage of atomic energy development, the heat cannot be converted to useful electrical energy and must, therefore, be discharged in the cooling air. (This by-product heat is being utilised to warm some of the buildings at Harwell.) It is the function of the pile to be an experimental tool of the greatest possible general use and not a source of industrial power.

The basic calculations for the new Harwell pile were begun in 1945 by a team of scientists working under Sir John Cockcroft in the laboratories of the National Research Council of Canada, and were continued when the team moved to the newly formed Atomic Energy Research Establishment at Harwell. Design of the pile began in 1946. From original conception to completion, the pile has, therefore, been rather more than two years in construction.

* The first three letters of this word are the initials of 'British Experimental Pile'. The 'O' was added for the sake of euphony.

Much of the material and equipment was made by private firms and Government factories. Considerable engineering difficulties had to be overcome. For example, the pile was built in an aircraft hangar, part of the roof of which had to be raised at the same time as excavations were in progress for the foundations of the pile. This was accomplished by erecting a Bailey bridge over the excavation to support the roof during its reconstruction. Many control components were made in the Royal Ordnance factories, and the uranium metal was cast at the Rocksavage factory of Imperial Chemical Industries and at the Ministry of Supply factory at Springfields. The Royal Dockyard at Devonport fabricated and erected the main steel framework of the pile, to a degree of accuracy far higher than is usual in a structure of the type.

The successful completion of the pile is the result of hard work on the part of scientists and contractors at Harwell with the co-operation of many outside groups. As we are no longer under the compulsion of war, the fact that time schedules were well maintained means that, although the Harwell establishment got off to a slow start, it is now in a most healthy condition and can be expected to make steady progress.

The continuous operation of a uranium power pile is of the greatest importance in the scientific life of the country, although its benefits will not be apparent immediately. A large proportion of the physical research, both fundamental and applied, will probably be able to be published, but of more immediate effect will be the availability of larger supplies of tracer isotopes. Until now, supplies have either been made in the Gleep, in which case not very large amounts could be prepared, or else imported from the United States when their use was restricted to medical and biochemical researches. It will now be possible to supply all the radio-active iodine, phosphorus, sulphur and carbon which will be required in medicine and biochemical research, and to extend the supply of these and other isotopes to industrial users. In fact, any adequately equipped research laboratory will be able to get radio-isotopes from Harwell, subject always to the provisions of the Radioactive Substances Act. It is from the use of radioactive isotopes in

many different researches that the first important results may be expected.

## Gravity Survey in the Channel

THE facts that geologists have to work upon are confined to those that can be obtained where rocks come to the surface of the earth, supplemented here and there by information on deeper structures obtained by borings. Thus there are many places in which gaps in the factual record have had to be filled in by inference. One such example is the English Channel, where naturally little direct observation of rocks is possible. Our knowledge of its structure is therefore mainly based on extrapolation from the data obtained by geological surveys of northern France and southern England. In Hampshire there is an area of recent (Tertiary) rocks, making up the Hampshire Basin. On the opposite side of the Channel lies the Paris Basin, containing similar rocks. For lack of evidence to the contrary, it has been assumed that these are but two parts of one basin, extending continuously under the Channel and appearing as land on either side. The rocks around Plymouth are of a much older date (Upper Palaeozoic), and those that face them on the French coast belong to the same period. Once more it was natural to assume that these were merely the two ends of a continuous formation.

Recently, however, some evidence has been accumulating which tends to show that the geology of the Channel is really more complicated. During the laying of the PLUTO pipe line from Southampton to Normandy, numerous echo-soundings and bottom samples were taken; and as a result of these Professor W. B. R. King has suggested (in a paper recently read to the Geological Society) that the region between the Paris and Hampshire Basins has been subjected to earth movements which produced a series of folds and brought the older (Triassic) rocks to the surface in the middle of the Channel. And seismological methods (observations of the times of return of the sound waves caused by the explosions) have led to the belief that the floor of the Channel south of Plymouth consists of less rigid rocks than those on the land around Plymouth and the corresponding French coast. The most probable explanation of this would be that the old rocks to the north and south in these parts dip deeply under the Channel, forming a trough filled with more recent sedimentary rocks.

One main object of the most recent submarine gravity survey of the Channel was to provide evidence for or against these new hypotheses. Measurements of gravity cannot themselves give direct information about the rocks beneath. But given any hypothesis concerning the rock structure, it is possible to calculate what force of gravity is to be expected. If the experimental determinations are in agreement with those calculations, then we have confirmatory evidence (though not conclusive evidence) for the hypothesis. If the experimental result differs widely from the calculated, then the hypothesis is as good as damned. The results of the survey should make it possible to decide fairly definitely between the hypotheses outlined above.

This submarine survey was carried out in May by Mr. B. C. Browne, Dr. R. I. B. Cooper and Mr. R. L. G. Gilbert of Cambridge University's Department of Geology and Geophysics, the submarine for the investigation being provided by the Admiralty through the Naval Research Facilities Committee. Though it will take some months to work out the results, it is known that the survey was a complete success in that all the instruments worked satisfactorily.

Gravity measurements are made by observing the times of swing of a pendulum—the faster the swing, the greater is the force of gravity. In order to carry out the experiments it is necessary to have very steady conditions, and these are not obtainable on the surface of the sea even in a dead calm. For that reason the survey had to be made in a submarine, for under water the disturbances of the waves, if not completely obliterated, are at least reduced to manageable proportions. Even eighty feet beneath the sea, however, there can be sufficient disturbance of the support of the pendulum to affect its behaviour seriously and upset the whole experiment. For that reason it is necessary to use the more complicated apparatus originally developed by the Dutch scientist, Professor F. A. Vening-Meinesz, the principles of which are illustrated diagrammatically in Fig. 1. Although the behaviour of a single pendulum is affected in a complicated manner by disturbances acting on its support, this is not true of the

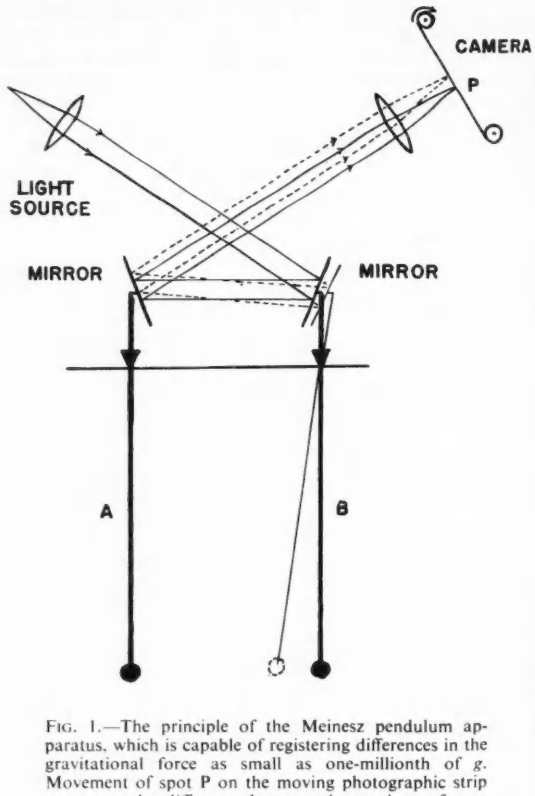



FIG. 1.—The principle of the Meinesz pendulum apparatus, which is capable of registering differences in the gravitational force as small as one-millionth of *g*. Movement of spot P on the moving photographic strip represents the difference between the motions of pendulums A and B, which is practically independent of the movement of the common support. (*From "British Science News", Vol. 1, No. 4; by courtesy of the Editor.*)

The three Cambridge scientists on the conning tower of the submarine in which they carried out their gravity survey of the English Channel. *Left to right:* The submarine commander, Lt. Raikes, R. L. G. Gilbert, B. C. Browne and Dr. R. B. Cooper.

relative behaviour of two pendulums of identical periods mounted on the same support. In fact the difference between the motions of the two pendulums is almost independent of the movement of the support. The diagram shows how this property is used to give a result equivalent to that which would be obtained from a single pendulum on a motionless support.*

The voyage also provided the opportunity to test a new gravimeter developed by Mr. Gilbert, which proved successful. In this instrument a weight is suspended on a wire which hangs between the poles of a magnet. The wire is made to vibrate at its natural frequency by passing an alternating current through it. The natural frequency depends on the force acting on the weight—that is, on the value of gravity. The peculiar advantage of this gravimeter over other types is that it will function even when the support is moving up and down (as in the conditions in a submarine). If, for example, the common type of gravimeter, which is equivalent to a very accurate spring balance, were used, the accelerations upwards and downwards would affect it so much as to render it useless. But with the new type of gravimeter it is only necessary to count the vibrations over a period of time which is long compared to the period of movement of the support; the oscillations will sometimes be quicker and sometimes slower than the 'true' frequency, but if the magnitude of the fluctuations is known, the true value of gravity can be calculated.

* In practice the apparatus is rather more complicated—three pendulums are used, one in the middle as nearly stationary as the support will allow and one on either side swinging in opposite phases. Besides arranging for equal and opposite forces on the support to cancel out, this allows a correction to be made for the fact that no two pendulums can ever have exactly the same period. A further refinement introduced in the apparatus used on this cruise was an electronic stabiliser which helps to compensate for the movements of the vessel. The oscillations of the pendulums were recorded on photographic strips, which also recorded time intervals from a quartz-controlled chronometer, accurate to one part in ten millions. The accuracy of the chronometer was itself checked from time to time against the very accurately controlled frequencies of the B.B.C. Very precise methods were used to fix the submarine's position, involving the use of radar when on the surface and, while under water, a taut wire anchored to the bottom by a sinker, which, as it was paid out, indicated the vessel's rate of travel over the ground.

## Essence of Archimedes

WHEN Archimedes determined his specific gravity by overflowing the bath he provided the means for detecting a clever law-breaker. The jeweller of Syracuse, who made the crown that set Archimedes thinking about density determination, was no doubt convinced that an aesthetic triumph justified a slight debasement of metal, particularly if there were no means of discovering it, but from his time right up to the present day the discoveries of science have been continuously employed to correct that error in the theory of jurisprudence.

It is common in legal and political circles today to talk of the conflict between natural and administrative law. One school argues that men will do what seems naturally right but will be morally undermined when a host of man-made restrictions invite evasion. The rationing of petrol is just such a restriction, and this argument is enhanced by the way in which petrol has been diverted in the past to the black market.

The Russell Vick Committee has now called in Archimedes to convert the waverers with the certainty of detection, and the publicists of the Ministry of Fuel have conjured up the spirit of Archimedes and of every other scientific detective in the campaign to persuade the motoring public that there will be no way round the anti-black market measures which have been put into effect and which depend on the labelling of commercial petrol. Here was

an opportunity to dazzle, even to blind, the public with science in a good cause, and full use was made of this opportunity.

The labelling is for all practical purposes as indelible as a radioactive tag (which one of our radio-chemist friends considers might have been tried though it would have required a general issue of Geiger counters to the police force!), and its introduction has had, we are glad to know, the desired effect.

The chemist has provided the means of labelling commercial petrol with as much certainty as methylated spirits remains methylated whatever treatment is given it.

However, within a few days of the first coloured petrol going to the garages the air fairly hummed with rumours of all kinds of tricks of amateur alchemy which would take the red dye out of commercial petrol. The success of wartime measures in decolorising Service petrol raised hopes that some simple filtration would be effective. One enterprising motoring correspondent, J. D. S. Alan of the *Sunday Dispatch*, after trying all the infallible methods that were being recommended, did a public service by writing an account of his dismal failure to take out the dye by filtering the petrol through starch, naphthalene, bread and a civilian gas mask. None of these worked, not even the last one. ("The first few drops seemed clear. The first half cupful had a suspicious tinge of pink, and none of that distinctive, yellow, slightly greasy appearance of private pool petrol. The next half cupful was almost as red as the original spirit.")

The advocates of the use of the gas mask filters were nearest to success, of course, and there is little doubt that a few experiments with different grades of animal charcoal instead of gas-mask charcoal would lead to a solution of the problem of producing colourless petrol. But the experiments would be a waste of time, for two other ingredients besides red dye have been added to commercial petrol. The first of these is diphenylamine, the presence of which can easily be detected by a colour reaction. The Ministry of Fuel's instructions explain how the test is carried out:

"*Shake 20 mls. petrol sample with 10 mls. 2N NaOH for 1 minute; run off the aqueous layer and repeat with a further 10 mls. of 2N NaOH. After running off the alkali, wash the petrol with 10 mls. water. The washed petrol is shaken with 2 mls. 0·1% ammonium vanadate in 70% HCl. The presence of diphenylamine is indicated by the appearance of a blue colour in the aqueous layer.*"

If analysts took the instructions literally they would find themselves in some difficulty, for 70% HCl is a substance unknown to science; the greatest concentration of hydrochloric acid obtainable in water at normal temperatures is 42% and not even a dozen Statutory Rules and Orders could make it any more. Joking aside, however, this test does incidentally give a clue indicating how diphenylamine can be removed; evidently a simple acid wash would be sufficient. (Methods of 'cleaning' petrol with concentrated sulphuric acid are given in every text-book of petroleum technology, in which acid washing is a routine practice.)

Unfortunately for those who don't want to observe petrol rationing regulations there is a third and undisclosed substance whose presence should baffle all the black marketeers (unless they happen to keep a first-class chemical engineer on the pay roll). *Reynolds News* has suggested that the only sound method of removing this substance, but one requiring a considerable organisation, is to build an illicit still—which shows a fundamental approach, since petrol could easily be freed from the dye and diphenylamine of boiling point 302°C. But the third compound closes this particular way out, as it has a boiling point in between the limits of petrol distillation which may range between 60°C and 160°C. For the benefit of all our law-abiding and technical-minded readers we would add that it has some anti-knock value.

## Penicillin Black-out Lifted

JULY 1, 1948, was a red-letter day for many scientists, for on that date the deadlock over publication of details about the chemistry of penicillin came to an end. For many months such details were treated as top military secrets, and very few of them were allowed to filter through the extremely fine sieve of censorship. Then the censorship was replaced by a gentleman's agreement between British and American scientists not to publish accounts of wartime work in this field until after the joint Anglo-American monograph compiled under the auspices of the National Academy of Sciences in Washington had appeared. Originally scheduled to appear in 1947, this monograph has been so long delayed—it is still not yet ready, though early publication by Princeton University Press is promised—that scientists on both sides of the Atlantic were forced to decide that the hold-up of information about penicillin could no longer be tolerated, and by mutual agreement the gentleman's agreement not to publish came to an end on July 1.

There are not, and have not been for a considerable time, any grounds for keeping details of this research secret, and it would have been unreasonable to expect the British workers, who did all the pioneer work in the penicillin field and more than pulled their weight in the early development phase, to have waited any longer. No time was lost after the removal of the ban; indeed on the very day it was lifted *Endeavour* came out with a most important review article on the chemical properties and structure of the penicillins. Most appropriately the author of the article was Dr. E. Chain, of the Sir William Dunn School of Pathology at Oxford, whose pioneer work in this field was recognised in 1945 by the award of a Nobel Prize. The article (which will be concluded in the October issue of *Endeavour*) is based on the chemical reports, nearly seven hundred in all, prepared during the Anglo-American research on penicillin during and since the war, and now available for inspection in certain British and American libraries. The account is of interest both because it shows in considerable detail the steps which led to the final elucidation of the penicillin structure and because it names all the different British and American organisations which took part in the effort and shows clearly the part played by each.

## Atomic Pin-Table

ONE of the physicist's common routine jobs is to measure the energies of nuclear particles—for example, alpha particles—given off by radioactive materials (energy being,

of course, half the mass multiplied by the square of the velocity). A few years ago this was commonly done by observing how far they would travel through a given gas, watching the tracks by such devices as the cloud chamber. But such a method is inconvenient to use, especially when it is required to sort out and record the energies of a very large number of particles expelled successively from the sample. Now if alpha particles could be persuaded to roll up a slope, we should be able to measure their energies directly by the heights they would reach. Furthermore if they were projected diagonally we could set up a line of pockets in pin-table fashion, such that all particles of a given energy would fall into one pocket, a different pocket for each energy. Then we could conveniently count the number of particles in each pocket at the end of the experiment.

Nuclear particles will not, of course, roll up slopes like this, or drop conveniently into pockets. But an ingenious apparatus recently developed by Prof. O. R. Frisch and Mr. G. G. Scarrot, of the Cavendish Laboratory, makes them do something very nearly the same. To be precise, each particle causes a small 'billiard cue' to propel a steel ball across a sloping table with an energy which is very nearly proportional to that of the particle itself. The balls then sort themselves by energies into a series of parallel grooves, where they can be counted.

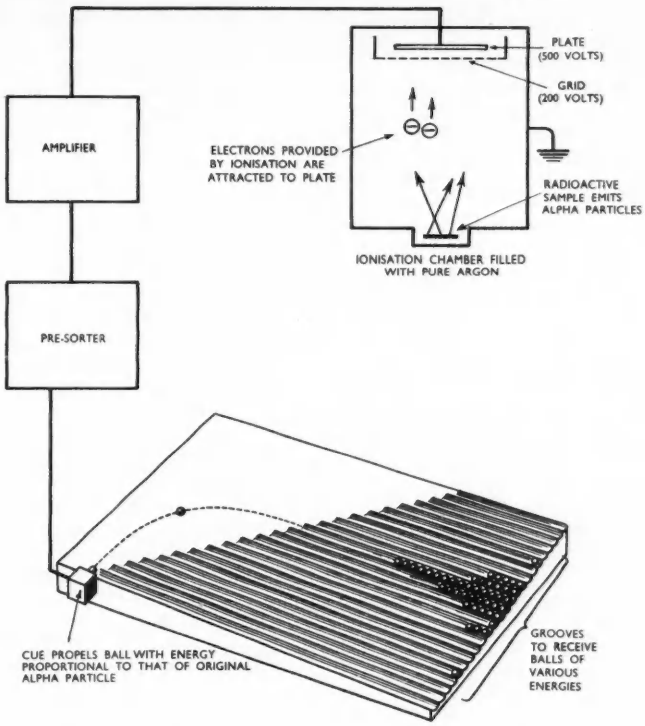


PLATE
(500 VOLTS)
GRID
(200 VOLTS)
AMPLIFIER
ELECTRONS PROVIDED BY IONISATION ARE ATTRACTED TO PLATE
RADIOACTIVE SAMPLE EMITS ALPHA PARTICLES
IONISATION CHAMBER FILLED WITH PURE ARGON
PRE-SORTER
CUE PROPELS BALL WITH ENERGY PROPORTIONAL TO THAT OF ORIGINAL ALPHA PARTICLE
GROOVES TO RECEIVE BALLS OF VARIOUS ENERGIES

FIG. 3.—This diagram shows the principle of Professor Frisch's apparatus for recording energies of individual particles liberated when atomic nuclei disintegrate.

The apparatus is illustrated diagrammatically in Fig. 3. Alpha particles, for example from a radioactive substance, pass into an ionisation chamber filled with pure argon. Each alpha particle in passing through the gas ionises a number of atoms proportional to its energy, and the electrons so produced are attracted to a plate at a potential of about 500 volts. On the way they pass through a wire grid at about 200 volts, whose purpose is to ensure that all electrons produce equal effect at the plate. The number of electrons reaching the plate is proportional to the energy of the alpha particle, and these in turn produce a small current pulse again proportional to the energy of the particle.

The current pulse is amplified and then passed to an electronic 'pre-sorter' where it is subjected to three operations. First, pulses too large or too small for the apparatus are removed. Secondly, the apparatus is blocked for about one-fifth of a second after each pulse to allow time for the supply of a new ball on the table. Thirdly, the pulse, which is a mere peak about 10 microseconds in length, is lengthened into the rectangular pulse of about one-hundredth of a second which is necessary to operate the mechanical stage which follows.

This lengthened pulse now operates a small 'billiard cue' in such a way as to propel a steel ball (an eighth of an inch in diameter) with an energy nearly proportional to the height of the pulse and so to the energy of the original alpha particle. The ball rolls in a parabolic path on an inclined plane and eventually falls into a groove appropriate to its energy. Immediately, a new ball is automatically deposited in front of the cue, and the process is repeated when the next alpha particle passes through the ionisation chamber. As the successive balls accumulate in the grooves, they build up a graph indicating the distribution of energies of the original particles.

## George Stephenson (1781–1848)

IN history text-books it is usually said that the main creative advances of the industrial revolution derived not from scientific discovery, but from the empirical inventions of untutored yet ingenious craftsmen. Leaving aside the chemical industries, this statement contains a great deal of truth. One finds that the men with a thorough training in mechanics and allied sciences were not prominent among those who invented the machines that transformed the world, while the majority of the great scientific discoveries in the period 1750–1850 had to wait many decades before they had a pronounced effect on industry.

Yet a study of the lives of many of the inventors of the period reveals that while they began as 'untutored craftsmen' they soon found it necessary to learn what the science of the day could teach them and to apply it to the inventive tasks they set themselves. They did not make scientific discoveries, but they applied the discoveries of others. They learnt, too, something of the systematic method of science and used it in solving their problems, so that many of the important inventions of the industrial revolution

are found on detailed examination to involve much less empirical ingenuity and much more systematic experiment than is usually assumed.

A good illustration of this point comes from the life of the founder of the modern railway, George Stephenson, the centenary of whose death fell on August 12. Stephenson began his career as 'untutored' as one could expect to find. Born in 1781 in miserably poor circumstances, he did not even learn to read till he was eighteen. Already at the age of fifteen he had begun a thorough empirical study of the mine pumping engine which was under his charge, taking it to pieces in his spare time in order to understand its working. Doing this he realised that to progress further as a skilled workman (which was then the height of his ambition), he must have access to the literature of science, and so in 1799 he started to attend night-school. Meanwhile he spent much of his time in attempting inventions and making mechanical models. But his essentially non-scientific approach at that time is shown by the very great effort which he put into attempts to find perpetual motion. Then about 1803 we find him studying the principles of mechanics as well as he could with the very limited opportunities available to him.

In the following years he performed prodigies of skilled engineering; for instance, in 1810 he made to work a Newcomen engine which the best engineers in the district had failed to get going. Yet still he was too ignorant of basic principles to be more than a highly skilled and ingenious workman—even in 1812 he was still searching for perpetual motion. By this time he was greedily learning all the science he could from his better-educated friend, John Wigham. He came to the decision that his only son, Robert, should never suffer from these same disadvantages, and with considerable sacrifice he sent Robert (then 12 years old) to school in Newcastle in 1815. Moreover, he used the boy to complete his own education. Young Robert Stephenson spent some of his time in the rooms of the Newcastle Literary and Philosophical Society, borrowed books to bring home and copied others which were not available for borrowing. Together father and son studied all the scientific works they could lay hands on, and when Robert went to Edinburgh University in 1820 he took down the lectures verbatim and transcribed them so that his father could read them.

It is about 1814, the year in which he built his first locomotive, that Stephenson's gradually increasing knowledge of science begins to show small but distinct effects on his methods of working. His first locomotive was much superior to any of the other attempts which had recently been made towards replacing the horses by steam on the then common minehead railway. But the superiority was due to good practical engineering rather than to innovation based on scientific analysis. However, Stephenson did show some use of scientific method in one respect—several of the earlier pioneers had asserted, apparently without experimental evidence, that the friction of iron on iron would be insufficient to propel a train, and had resorted to rack-driven locomotives and to even more curious devices; before building his locomotive Stephenson took the trouble to satisfy himself by very simple experiments that the friction would be sufficient, and so worked on the right lines from the start. The following year he made the key invention in locomotive design—the use of exhaust steam to create a draft. Though direct evidence is lacking it is reasonable to assume that this idea owed something to his recent scientific reading; for in the past 15 years the scientific literature had been full of devices for pumping based on similar principles applied to liquids, arising in the first place from the work of Venturi.

In 1815 Stephenson was much occupied with his invention of the miner's safety lamp, the credit for which he shares with Davy. His approach to this problem cannot compare with the classic scientific analysis by which Davy solved it; yet his methods were clearly becoming more and more scientific—he did systematic experiments both in mines and at home with apparatus loaned by the Newcastle Literary and Philosophical Society on such questions as the velocity of flame propagation and whether flames would pass along tubes of small diameter. The theory by which he interpreted his results was wrong, but the experimental results and the application which he made of them were correct.

Continuing with his work on railways, Stephenson turned in 1818 to the problem of the track, and it was here that his methods became most fully scientific. He made systematic experiments, using a dynamometer of his own construction, on the various resistances which the locomotive had to overcome. Among other things he verified, in a way that for the first time convinced engineers, a fact that had previously been discovered by Coulomb and Vince, namely that the friction is independent of the velocity. His experiments led to a thorough understanding of how the work of the locomotive was distributed between overcoming gravity and overcoming friction and similar resistances. It was from this work that Stephenson learnt the principle of gentle gradient which made railways practically possible. Another application of directly scientific method occurred in 1829, when constructing the 'Rocket'. It was known that the blast in the chimney could be increased by contracting the exhaust outlet, but it was uncertain whether the resulting back pressure in the cylinder might not offset the advantage so gained. Stephenson again used systematic experiment, measuring smoke box pressures by means of a simple manometer, with the result that the 'Rocket' was designed with about the optimum amount of contraction of the exhaust pipe, whereas a rival locomotive using the same idea but without the benefit of scientific analysis was an almost total failure.

Needless to say, this view of Stephenson as the user of scientific method will not alone explain his success. There is also Stephenson the skilled worker, and Stephenson the undaunted, who persevered in building the line across Chat Moss when all the experts declared it impossible, and Stephenson the political fighter, who met and eventually vanquished the tremendous forces which vested interests put up against him. But these alone would not have been sufficient without the scientific method—crude, yet essentially the method of modern science—by which he provided himself with the fundamental technical data on which his great engineering achievements were based. There is really no very great distinction, except in the polish that comes with time, between the way in which Stephenson and others like him used the scientific knowledge of their times as a guide to their practical work, and the way that an applied scientist of today uses the fundamentals of electromagnetism and electronics to create radar.

# The Snares of Carnivorous Plants

RICHARD CLEMENTS, B.Sc., F.L.S.

THAT plants can and do capture and 'eat' animals has been known for many years. There are in fact about 450 species of plants which do so. But popular stories of man-eating trees have to be accepted with the utmost reserve. The favourite cover-illustration for a hair-raising tale of one of these man-eating trees is a lurid picture of a plant like a tree-fern whose long leaves have entrapped a beautiful damsel.

Stories of these remarkable man-eating plants were at their height at the beginning of this century, but they are trotted out occasionally even now. In 1851 a Captain Arkright said he had discovered a Devil Flower which grew on El Banoor, or Island of Death, an atoll in the South Pacific. This flower was so large that a man might enter it—"a cave of colour and perfume". If he did though, it was the last of him, for lulled by the fragrance he went into a deep sleep during which the flower folded its petals over him and his body became food for the plant.

Another story is that by a Mr. Dunstan, an American naturalist, who spoke of a flesh-eating vine which attacked his dog while he was plant-hunting in the swamps of Nicaragua. A snake-tree has also been described in newspapers as having been found near the Sierra Madre in Mexico. This tree is supposed to have sensitive branches of a snake-like appearance, and when a bird alights on them it is seized, drawn down into the tree and is lost to sight. One traveller told how having touched one of the branches of the tree it closed upon his hand with such force as to tear his skin.

One of the most oft-quoted stories is of the man-eating tree of Madagascar to which human sacrifices are made. It was first reported by a Dr. Carle Liche who claimed to have seen such a sacrifice in 1878. According to Dr. Liche's story which appeared in many journals, including some scientific ones, and which reappeared in the *American Weekly* as late as 1920, the tree, regarded as sacred by the natives, had the appearance of a gigantic pineapple. It had a strange barrel-shaped trunk about ten feet high, from the top of which there hung eight leaves, ten to twelve feet long, a foot wide and tapering to a needle-like point. Each leaf bore numerous venomous thorns.

Dr. Liche was taken to see the tree one night when a human sacrifice was made to it. A young girl was forced by the natives to climb to the top of the tree and drink the liquid found there.

"I expected to see her jump down, thinking all was over . . ," Dr. Liche wrote to a friend. "Suddenly I realised what was happening and I seemed to be paralysed with horror. The tree, seemingly so dead and motionless a moment before, had come to life. . . . The green branches so rigid before began to writhe and coiled themselves round and round like snakes. Then as that mass struggled there arose a horrible sight I shall never forget—the great leaves began to rise slowly, very slowly. Those evil-looking thorns were now closing on her with the force of a hydraulic press . . ."

Unfortunately for the veracity of the writers of these thrilling tales, no animal-eating (carnivorous) plant has yet been scientifically investigated which tackles anything larger than small birds, toads or lizards. But the method of capture is often far more complicated and interesting than anything yet thought up by fiction-writers.

Most animal-eating plants live in marsh or water. It is assumed that the capture and consumption of insects and other small animals adds to the plant's supplies of nitrogen. The majority of these plants can live without animal nitrogen, but there is no doubt they are stronger and healthier if they have it.

The number of ways in which plants capture their prey is many and varied. They include simple pitfalls as in the well-known pitcher plants, sticky fly-paper traps (e.g.,

## THE THREE GENERA OF BRITISH CARNIVOROUS PLANTS

FIG. 1.—The Common Butterwort (*Pinguicula vulgaris*).

FIG. 2.—Three species of Sundew grow in Britain. This is the Round-leaved Sundew, *Drosera rotundifolia.*

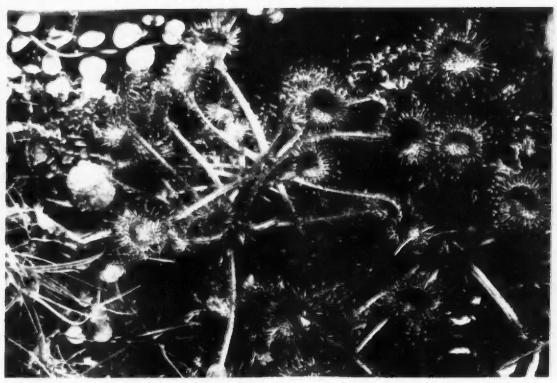


FIG. 3.—The traps of the Bladderwort (*Utricularia*).

*(Figs. 1-3 and the cover picture are copyright by Harold Bustin.)*

the Sundew), lobster-pot traps as in *Genlisea*, steel-traps of the Venus's Fly-trap (*Dionaea*), and the most beautiful and complicated self-setting 'mouse-trap' of the Bladderwort.

The efficiency of the various snares is aided by such lures as odour, secretion of honey and nectar, or the exhibition of attractive colours. In others, insects are enticed to their doom by the brilliant points of light reflected from drops of mucilage or are guided into the trap by hairs.

When the prey has been caught most of these plants secrete enzymes around and over the body to help digest the animal. Something akin to the stomach of an animal thus results when the prey and digestive juices are all brought together in some sort of a receptacle.

It is not the higher plants alone which are carnivorous —many fungi are wholly dependent on animals for their food.

The pitcher traps of *Heliamphora*, *Nepenthes*, *Sarracenia* and others are perhaps the simplest kind of snare, in that there is no movement of the plant to entrap the animal. It is left to the insects to fall into the trap; albeit they are helped to their doom by numerous lures. Once inside the trap they are prevented from escaping by downward pointing hairs and the slippery, unclimbable pitcher sides.

*Heliamphora*, a plant which grows in regions of high rainfall in South America, bears graceful funnel pitchers a few inches long. Each pitcher has a small spoon-shaped lid. This lid does not, as is popularly supposed, close the top of the pitcher when an animal enters. The pitcher is normally half-full of water in which animals fall and drown. To prevent the receptacle filling to the top there is a small pore half-way up the funnel which acts as an overflow.

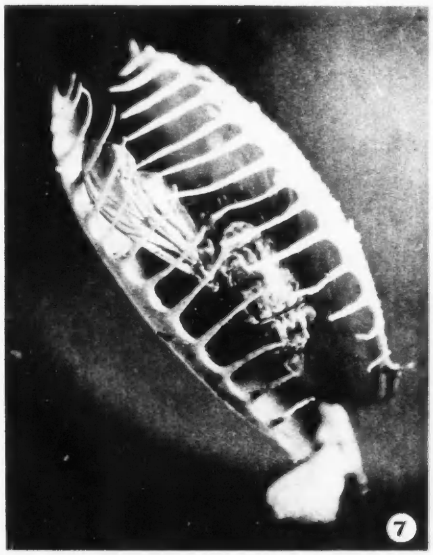
No digestive glands have been found in the pitcher of *Heliamphora*. As there is always a decaying odour associated with these pitchers it is thought that the proteins of the animal bodies are made available to the plant by bacterial digestion.

Another pitcher plant, *Sarracenia*, found in North America, lures the insects to the mouth of the pitcher by a nectar-baited pathway up the outside of the trap. Inside these pitchers there are four easily recognised zones. The topmost is an area of attraction which gives an insecure foothold to insects venturing on to it owing to the form of the hairs there and the direction in which they point. The next zone lower down attracts the insects still farther by means of nectar. Overlapping ridges in this area give little foothold to insects. The next zone is a glandular area, smooth and glassy in appearance. There is no foothold at all here. The bottom zone has numerous pointed, long, glassy, downwardly directing hairs which prevent the prey from escaping.

Professor Lloyd carried out experiments with a bluebottle fly and a *Sarracenia* pitcher to see how the trap worked. The fly was soon attracted by the nectar secreted by the glands of the external surface and gradually worked his way up by an erratic path to the rim. Mounting this, he began to sip the nectar on the under-surface of the lid, holding on to the edge of the rim by his back legs. He seemed to be aware of his insecure foothold and was loth to free his hind feet to explore further. Sooner or later, though, he overreached himself and fell into the pitcher. A small piece of the pitcher wall was cut out to enable him to escape each time, and he then repeated the performance over and over again.

The brilliant red and green pitchers of *Nepenthes*, a well-known greenhouse plant, are probably the most familiar of any. *Nepenthes* grows in jungles and marshes in the tropics, sometimes climbing to the tops of tall trees. Each pitcher is formed at the end of a tendril, which is itself a continuation of a leaf, the tendril twining about a support so that the pitcher is held in an upright position. Among the rarer species of *Nepenthes* is one which has a pitcher twenty inches long and a stalk up to twenty feet in length; another plant from the mountains of Borneo has pitchers twelve inches across and holds up to seven pints of water in which small mammals or birds drown. One of these was exhibited at the Horticultural Hall, London, where the odour of the plant attracted large insects and even mice.

Carnivorous plants in fiction and fact. FIG. 4.—A newspaper artist's conception of Dr. Liche's man-eating plant. FIG. 5 (*inset*). Nearest approach to the imaginings of science fiction writers is a pitcher plant, similar to the species shown here, with pitchers a foot across and holding 7 pints of liquor. But this cannot cope with anything larger than a bird or a mouse.



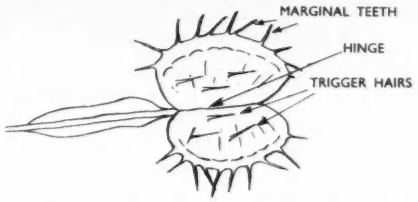



FIG. 6.—Plants of the N. American pitcher plant (*Sarracenia*); and *Drosophyllum*, the 'fly catcher' of Portugal, Morocco and Spain, with its long, narrow, sticky leaves. Photograph taken in the insectivorous house of Kew Gardens.

FIG. 7.—A Venus's Fly Trap closing on a fly.

FIG. 8.—Details of the Venus's Fly Trap.

Remarkable large alluring glands, among the most highly developed structures in the plant kingdom, are found scattered here and there among the leafy parts of the plant and attract small wandering animals. Many small digestive glands—up to 6000 per sq. cm. in some species —are found on the internal walls of the pitcher.

The rim around the opening of the pitcher bears numerous downward-pointing teeth, with nectar-secreting glands between them. Below the rim are several distinctive zones. The uppermost is a 'slide' zone, covered with a waxy secretion giving an opalescent appearance to this area. The waxy secretion is in the form of scales, overlapping like roof tiles. Any insect which tries to walk over them causes the tiles to slip down over each other and carry the insect with them into the pitcher.

Below the slide zone is the detentive or digestive area bearing many glands with a digestive or absorptive role.

The pitchers themselves are usually half-filled with a limpid, colourless fluid which has a faint and agreeable odour and taste. Travellers in the Dutch East Indies have found there is sufficient liquid in half a dozen ordinary pitchers to satisfy a man's thirst. Bacteria are not usually found in the pitchers, which apparently contain antiseptic substances.

These traps, on the whole, are very efficient animal catchers: some have been found which were overloaded with centipedes, cockroaches, butterflies, scorpions, etc.

A much more complicated trap, using the principle of the lobster pot, is found in *Genlisea*, a swamp plant which grows in Central and South America. The traps are formed from leaves. Though small they are very complicated structures. They take the form of a bulb with a long tubular neck, rather like a flask, the top of which divides into two separate arms. Inside the neck and arms are a series of structures similar to lobster pots, with rings of downward-pointing hairs which prevent escape of the prey. Small animals entering the neck of the trap can only go one way, downwards, towards the bulbous portion where they are trapped and die. Small water spiders, nematodes, copepods and other small animals have been found in these traps. This whole snare is passive.

## Fly-paper Traps

An efficient sticky fly-paper kind of trap is used by *Byblis* and *Drosophyllum* and two British plants, the Butterwort (*Pinguicula*) and the Sundew (*Drosera*). The leaves of these plants bear many glands secreting mucilage which entraps any animal venturing on the leaf.

*Byblis* is an Australian plant, and its linear-shaped leaves bear numerous digestive glands as well as the mucilage-secreting glands. *Drosophyllum* is unusual in that it grows in dry places in Portugal, Morocco and Spain. This plant has a dewy appearance owing to the numerous glands on the leaves carrying large droplets of clear mucilage. Many flies are caught on its leaves, and in consequence it is known locally as the 'fly catcher'. A peculiar thing about the mucilage secreted by these leaves is that it is not drawn out into fine threads if touched

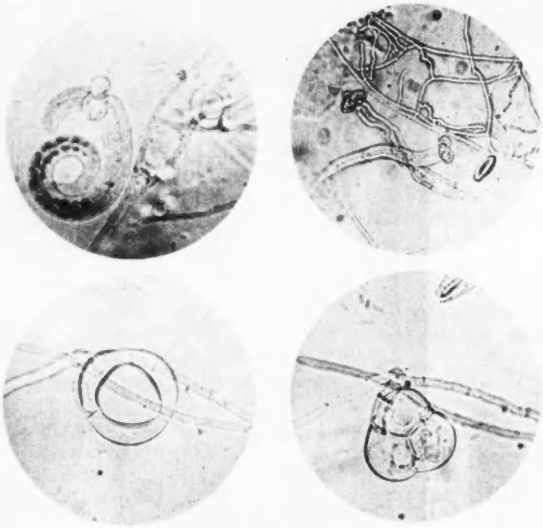


FIG. 9.—These four stills from the film, *Champignons prédateurs*, show how the fungus known as *Dactylaria* can catch and garrot nematode worms. The top photos show the three-celled noose which traps the worms. When a worm touches their inner surface, the cells swell inwards; this effect is demonstrated artificially in the lower pictures, being brought about by the insertion of a fine glass needle into the noose.

as is the mucilage of other plants, but it adheres in lumps to any insect which touches it. As the insect crawls along more and more drops stick to its feet, wings or body until it becomes bathed in the viscid solution and it sinks down and dies. Digestive glands on the leaf are stimulated to secrete by the catching of prey. Mosquitoes have been completely digested in twenty-four hours.

One of the few British carnivorous plants, the Butterwort (*Pinguicula*), also uses the sticky fly-paper trap. Its rosette of leaves glistens with myriads of minute mucilage glands. This mucilage entraps and smothers prey such as small aphids, flies, etc. With this trap, too, there is sometimes an infolding of the leaf margins when an animal has been caught on the leaf. It is thought this movement helps to retain fluids on the leaf and in some cases pushes the prey nearer the middle.

The Sundew, *Drosera*, another but more widely distributed British plant, grows in marshy areas, and catches animals on its sticky leaves. Insects are apparently attracted by a fungus-like odour and by the glistening mucilage drops resembling minute dew-drops that sparkle in the sun and which give the plant its name of Sundew. The leaves of *Drosera*, as those of *Pinguicula*, move when prey is caught. When an animal is captured by the long mucilage-bearing tentacles, other tentacles nearby may bend over towards the prey within a few seconds. The long, mucilage-bearing tentacles are very complex glands which besides secreting mucilage probably receive and transmit stimuli and secrete various digestive ferments as well.

A plant using a very different kind of mechanism—a snapping steel-trap type of snare—which Darwin thought the most wonderful plant in the world—is the Venus's fly-trap, *Dionaea*, found in North America.

The leaves of *Dionaea* have two lobes hinged along the midrib, each lobe bearing coarse marginal teeth. On the upper surface of each lobe are three slender, sensitive hairs—trigger hairs. When any insect touches one of these triggers the two lobes snap together in the fraction of a second, to catch the animal whose escape is further prevented by the marginal hairs which now interlock. The sensitive hairs work as a lever does, any slight movement at the end being magnified at the junction with the lobes. When the trap lobes are open, tensions are present which are so distributed that the two leafy halves are maintained in an open condition. But a touch on the sensitive hairs disturbs the balance and the lobes snap together, with the fringing hairs interlacing like the fingers of clasped hands. The midrib does not act as a hinge, however, the closing movement takes place in the two lobes themselves.

During the closure the outer faces of the lobes expand, the inner remaining unaltered. After the initial snap the lobes may continue to press against each other still more owing to chemical stimulation by the insect. Upon stimulation by the animal, digestive fluids are copiously secreted. The lobes later reopen by increased growth of their inner faces.

Another snapping trap is worked by *Aldrovanda*, a small sub-tropical fresh-water plant which grows just below the water surface. The traps, which are formed from the small leaves, consist of two semi-circular lobes. Opened, they have the appearance of a widely opened mussel shell. When the trigger hairs are touched the lobes spring together in one-fiftieth of a second. This rapid movement, caused by loss of turgidity of cells in the lobes, expels water from the trap, giving a jet effect which moves the trap in the water. Recovery of the trap is by growth. A trap reopens in a day or two, but if the prey is large and fills the digestive cavity the trap may never open again.

Perhaps the most precise and wonderful piece of mechanism in the plant world is shown by the 'mouse-trap' snare of the Bladderwort, *Utricularia*, a world-wide genus of aquatic plants, one species of which occurs in Britain. The Bladderwort has finely divided foliage and bears numerous pear-shaped bladders—the 'mouse-traps'. Each bladder, which varies from three to five millimetres in length, has a nearly circular entrance at one end, around which slender

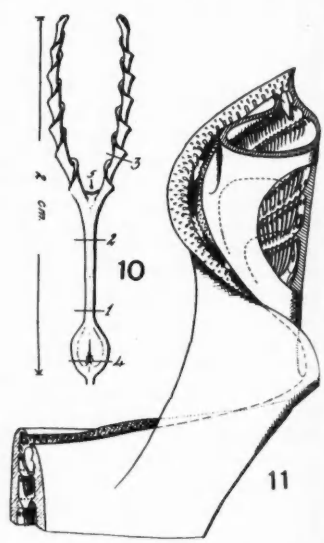



FIG. 10.—The 'lobster pot' trap of *Genlisea* is a modified leaf, and about an inch long. FIG. 11.—Part of the trap; this diagram shows the internal arrangement of detentive hairs. (*From Lloyd's "The Carnivorous Plants"*.)

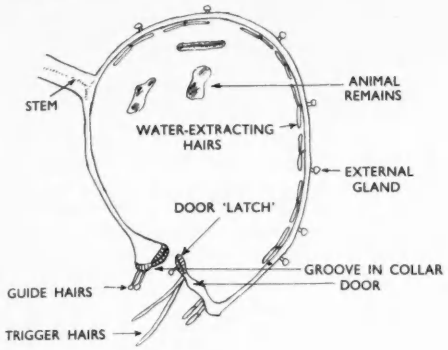
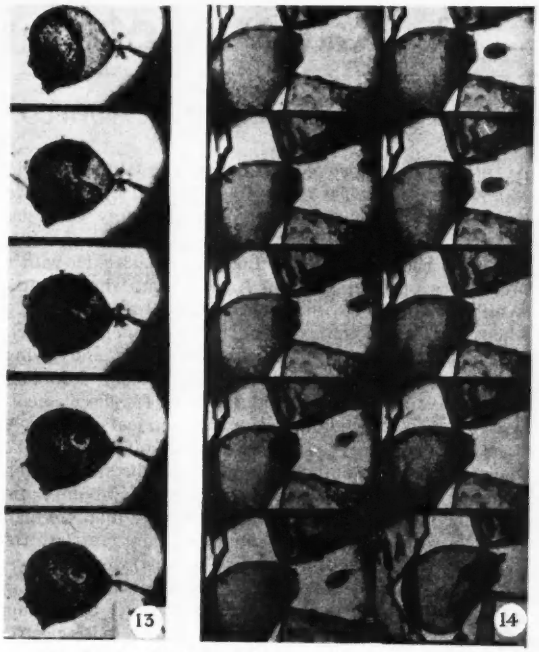



FIG. 12.—How the Bladderwort's trap is constructed.
FIG. 13.—Bladderwort trap (of *Utricularia purpurea*) showing the exhaustion of the contained water indicated by the distortion of a contained bubble of air. A moving picture spread over two hours. (*From Lloyd's "The Carnivorous Plants"*.)
FIG. 14.—This film sequence shows the capture of a water flea by *Utricularia vulgaris*. (*From Lloyd's "The Carnivorous Plants"*.)




bristles form a sort of funnel to guide prey into the trap.

The trap entrance is guarded by two valves; the larger one acts as a highly flexible door, and the smaller valve, known as the *velum*, lies against the lower edge of the door. The door can only open inwards into the trap.

When the trap is 'set' the door rests in a groove in a firm, semi-circular collar, while the chink between the collar and the door is closed by the thin velum. The outer surface of the door bears mucilage glands which attract small animals, and when these touch tapering bristles attached near the lower edge of the door and acting as a latch—or trap—mechanism, they set in motion a train of events leading to their capture.

Water is extracted from the trap by hairs inside the bladder. This sets up an internal negative pressure which causes the door to be tightly pressed against the groove in the collar by the external water pressure. If the trigger hairs on the door are touched they lever the door up from its groove where it is then forced inwards by the rush of water which carries the animal along with it into the bladder. When the pressures inside and outside the trap are uniform the door again closes. The trap is re-set in about thirty minutes, and only the 'bones' of the animal inside show what has occurred.

This trap operates so quickly that for many years nobody knew quite how it worked. Eventually Lloyd, aided by a ciné-camera taking pictures at intervals of one-hundredth of a second, elucidated the mystery.

A curious way of catching animals is shown by some fungi which attack eelworms. Their method is to lasso them. In one fungus, *Dactylaria*, three cells of the fungal thread form a loop. If an eelworm pokes his head or tail through the loop the ring immediately clamps on it by the sudden swelling of the cells. Later new hyphae penetrate the body of the prey. In some cases the inner surface of the 'hangman's loop' is adhesive.

Other fungi 'fish' for their prey. In one a round knob bearing a very sticky substance is borne on short hyphal branches. When an animal takes a bite it is caught by the adhesive.

Apart from the animals which are caught by the various plant traps, there are numerous animals which use the traps as dwelling places and feed on the ensnared victims. Ants, wasps, bees, butterflies and moths as well as larger animals such as toads and chameleons frequent the traps of *Sarracenia*, *Darlingtonia* and *Nepenthes*. In some cases animals breed to such an extent in the fluid of the pitchers that the liquids appear 'alive'.

One small animal, a capsid bug, somehow manages to live on the sticky surface of the leaves of *Byblis*. How it does this is a puzzle, because all other small animals venturing on to the surface of this leaf get stuck to it.

It is not surprising that carnivorous plants have figured in the folklore of people living in contact with them. As long ago as 1660 a traveller in the Far East noted that natives were unwilling to cut off pitchers from plants as they feared that if they did there would be a heavy downpour of rain. In periods of drought, though, natives go to the mountains and pick as many pitchers as they can so as to bring on the rain. The natives also think that pitcher fluid emptied over children cures them of enuresis.

Despite the long and excellent study of carnivorous plants by Lloyd and others, there are many problems connected with these plants still remaining to be cleared up. The mode of working of several of the snares has never been thoroughly elucidated, while the role of many animals living in or near the traps has yet to be worked out.

## READING LIST

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# A Rare Metal in Everyday Use

M. SCHOFIELD, M.A., B.Sc., F.R.I.C.

ALTHOUGH the history of tantalum may be said to begin in 1802, the metal itself is only 45 years old, if by 'metal' we mean something more than a small quantity of black powder.

Charles Hatchett, son of a London coachbuilder with a prosperous business in Long Acre, a man who was too wealthy to continue with his chemistry, set the ball rolling when he detected an oxide of a new element in black columbite, a mineral named after its origin and giving rise to 'columbium' for the element itself. Niobium should have been a good enough name for the element, since Niobe was the goddess of tears—and tears must have been shed in plenty by workers endeavouring to make malleable and ductile both niobium and the sister metal, tantalum. But the Americans named it 'columbium', and the name has stuck, since they did far more than German research-workers to harness columbium and tantalum for industry. It was Ekeberg, Swedish chemist, who went one better than Hatchett by discovering tantalum itself in Finnish columbite; and Moissan came nearer by making an ingot of impure columbium and tantalum in his electric furnace. But in 1903 Von Bolton of Charlottenburg converted tantalum powder into ductile filaments and opened up the industrial field.

During the period 1905 to 1911 tantalum made its first debut in electric-lamp filaments, displacing carbon filaments but becoming superseded in turn by the more efficient tungsten filaments. While full credit must be given to the United States, particularly the Fansteel Metallurgical Corporation of North Chicago, for taking the tantalum industry to its present high efficiency, the obdurate metal (which today is never melted nor cast, but rolled and drawn after processing by powder metallurgy) was first harnessed in Europe. Von Bolton reduced potassium fluotantalate with sodium, pressed the resulting tantalum powder into rods, melted these in the electric arc, and rolled the metal into sheet and worked it into filaments. After some hundred million tantalum lamps had proved serviceable, tungsten, with its yet higher melting point and efficiency as a filament material, was harnessed by that process which must be regarded as the metallurgist's greatest triumph. That process, which is also applicable to tantalum, is to compress, sinter, and swage the powder—'swaging' is a submission to several hundred hammer blows a minute from revolving dies, the whole operation being of necessity conducted in a vacuum where tantalum is concerned. Tantalum electric lamps still proved useful, on railroads, for example, where the filaments, tougher than those made of tungsten, proved immune to vibration or shock. But only D.C. lamps are possible: for tantalum filaments undergo a progressive crystallisation with A.C. current. Yet tantalum staged a come-back in vacuum tubes which has more than offset its disappearance in lamp filaments.

All the common properties of tantalum find corresponding applications on a large scale. It is a white metal with a look of platinum about it; hence we think of it as a substitute for platinum in jewelry and laboratory ware. Here indeed tantalum scores easily, for its price averages one-fifteenth that of platinum. It has appeared in watches, bracelets, "and all the hardware which women put on their persons", as Cobbett cynically put it.

The metal takes on an oxide film which is iridescent and of undoubted attractiveness to the jeweller. This tendency to oxidise, above 150°C, is the one flaw in the ubiquity of tantalum in resisting all types of corrosion. The tantalum crucible is useless except when used in reducing atmospheres. And yet, except when it meets hydrofluoric acid which attacks all metals that fail to take on a resistant coating of fluoride, tantalum is the supreme noble metal. Tantalum dishes are harder and cheaper than platinum, and of use on the water-bath to evaporate even *aqua regia*. Tantalum cathodes in electrolytic analysis are especially valuable; not only do deposited metals (such as zinc) fail to alloy with it, but gold and platinum may be deposited from solution and then removed from the tantalum by use of *aqua regia*. Analytical weights for standards of high accuracy need no longer be made of platinum: the Bureau International des Poids et Mésures in France and the U.S. Bureau of Standards have accepted tantalum for this purpose.

Outside the laboratory this supreme resistance of tantalum to corrosion has proved a boon in dealing with bromine purification, with phenol production, and especially in hydrochloric acid plants. Dr. C. W. Balke and his colleagues of the Fansteel Corporation have overcome very many difficulties in constructing chemical plant such as a heat-exchanger of 174 tantalum tubes each 5 ft. in length, and those large-scale hydrochloric acid plants completed by 1942 (by which time nearly 80% of American acid plants were produced in tantalum). In a recent lecture to the American Chemical Society and in papers published in *Industrial and Engineering Chemistry*, Dr. Balke has reminded us how both high mechanical strength and superior heat conductivity of tantalum come into the picture at this point. Compared with lead (commonly used in acid-resisting plant) the thinner-walled heaters and steam-coils are practicable with tantalum since it can withstand high internal steam pressures; and the consequent greater heat conductivity of such thinner metal layers results in a much higher rate of heating and evaporating the corrosive liquids. Chemical industry in the United States has adopted tantalum equipment for concentrating acids and for resisting the particularly corrosive action of some acid vapours at the moment of condensation.

In fountain-pen nibs requiring no iridium tip; in tantalum nozzles for chlorination of water supplies; and in dental and surgical instruments this highly resistant metal proved invaluable until stainless steel improved.

To mention surgical uses brings to mind yet another point which helped to place tantalum among essentials in war-time, a 'priority' which brought the construction of a 5-million dollar tantalum-producing plant by the United States Defence Plant Corporation, and saw the giant cargo plane *Mars* transporting tantalite ore from Brazil. Tantalum not only proved essential in chemical plants and

Dr. Clarence W. Balke holds in his hand a replica of the first commercial tantalum 'ingot' which he made in 1922. This bar weighed eight-and-a-half grams. On the table before him is a typical present-day tantalum bar weighing 6000 grams.

as hard carbide in tools and dies in war factories, but took on yet another role as 'biologically acceptable' material for repairing war casualties. Many thousands of skull injuries have been treated with tantalum plates; small bones have been repaired with tantalum wire and tubing of narrow section. Fine wire braided to make strong flexible sutures easily tied; tantalum wool and gauze used for replacing muscular tissue and as a bridge for growth of new tissue: these and other surgical uses have come from the discovery that tantalum is completely non-irritant to living tissues and remains inert after long exposure to body fluids.

Turning now to applications in the electrical field we find the first wide use in the Balkite rectifier and trickle-charger developed just when owners of radio sets in the United States were looking for a simple battery charger. It was Dr. E. W. Engle who noticed how tantalum behaved as an electrolytic 'valve' when alternating current was passed through a cell of tantalum and lead plates in dilute sulphuric acid. Yet another characteristic that has proved a boon was the high order of absorption shown by tantalum towards traces of gases at high temperatures—a factor which had proved a nuisance in first working the metal in hydrogen. Tantalum is not only a 'getter' for traces of unwanted gases, but is a 'keeper' in certain types of vacuum tubes where it is desired to introduce very small controlled amounts of gases. In vacuum tubes the radiation from tantalum is about equal to that with tungsten, nickel and molybdenum, though a good word must be given here for columbium. Some United States manufacturers are using tantalum for plates and grids, while all-tantalum vacuum tubes with plates, grids, filaments and support wires have been experimented upon. In the American electrical industry there has also appeared the tantalum condenser constructed from thin sheet metal made from porous powder. Producing such spongy sheets depends on the compression of particles of definite controlled size, followed by sintering in the electric furnace.

One or two instances where tantalum fails or proves inferior may be cited. Just as tantalum crucibles are useless in an oxidising atmosphere, so tantalum cannot be used in place of platinum as anode in the electrolysis of solutions, since an oxide film develops. In the British rayon industry much experimental work on spinnerets constructed of glass, artificial gems, platinum-gold and tantalum has been carried out, but only platinum-gold and tantalum remained for practical purposes. Tantalum has advantages in exceptional hardness and in cheapness—it does not attract the dishonest workman who might attempt to dispose of platinum on the black market! Yet for spinnerets holding alkaline viscose on one side of the perforated disc and exposed to a sulphuric acid bath on the other, platinum-gold has now returned, since tantalum attracts dirt or foreign matter in the spinning bath.

All developments in tantalum depend on one fundamental process or operation: the production of pure metal bars for rolling into sheet and drawing into wire, all from metal particles of controlled size. Dr. Balke in his recent

lecture points out how history repeats itself in a way, since both he and Charles Martin Hall were students under Professor F. F. Jewett. Whereas Hall went on to produce aluminium by dissolving bauxite in a molten fluoride bath and electrolysing the melt, Dr. Balke, in working for his doctorate degree and afterwards, turned to the preparation of tantalum, also produced eventually by dissolving tantalum oxide in a molten fluoride bath and electrolysing potassium fluotantalate. Both the crystalline metal powder, deposited on the walls of the cell, and scrap tantalum (from the machine shops), reduced to powder after heating in hydrogen to cause embrittlement, have to undergo the intense sintering (in the electric furnace) and swaging operations before sheet or wire can be produced. Gradually the plant for this has been increased in size to deal with bars weighing five kilograms and using the largest hydraulic press ever made for powder metallurgy (it transmits a pressure of 3000 tons to the face of the bar). But still tantalum is the tantalising metal in one direction. It hides itself in far-off places and there is not enough of it. Though mines at Black Hill, Tinton, South Dakota, yielded tantalum, the ore has proved of poor grade compared with the one rich source, the Pilbarra Mines of Western Australia. This richer tantalite is remarkably free from such undesirable impurities as titanium, tungsten and tin, and since it yields as much as 80 per cent of tantalum oxide, it is a major economic source. Recently, however, Brazil and the Belgian Congo have furnished new supplies of great promise.

READING LIST

"Tantalum and Niobium", Imperial Institute (H.M. Stationery Office, 1930).

"Rare Metals", Fansteel Products Corporation, N. Chicago.

Articles by Dr. C. W. Balke include two in *Industrial and Engineering Chemistry* (1935, **27**, 1166 and 1938, **30**, p. 251). See also his lecture, "The Story of Tantalum", published in *Chemistry and Industry* (1948, Feb. 7, No. 6, pp. 83–6).

## ROYAL SOCIETY SCIENTIFIC INFORMATION CONFERENCE

THANKS to an immense amount of preparatory work, and to the enthusiasm of the various working parties, the Royal Society Conference was able to present eighteen printed pages of recommendations at its final session, most of them so phrased that positive action should result. In these pages, no direct reference will be found to Professor J. D. Bernal's proposals for the central distribution of papers, and in fact they were not discussed by any working party. Owing to the widespread misunderstanding of the proposals and the prejudices aroused both by the proposals themselves and by misrepresentation of them in the press before the Conference opened, they were withdrawn. Little time was therefore wasted in ideological arguments, although at one point the guardians of liberty opposed the suggestion that the editors of journals in cognate sciences should co-operate by allocating papers received to the most appropriate journal, on the grounds that the liberty of the individual to send his paper where he liked would be infringed. (The astonishing thing about this argument is that several of the most respected scientific societies have always insisted that papers submitted to them become the property of the society, *whether published or not*, and may not be sent elsewhere without permission.)

On various occasions during the proceedings it was clear that many working scientists were completely out of touch with the progress that has already been made in the field of documentation and were ignorant of the facilities and services which are already available to them in dealing with the literature. Proposals which have been under consideration by bodies such as ASLIB for many years were greeted as revolutionary by some of the delegates.

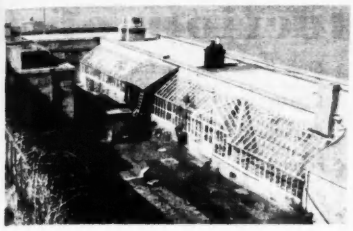
At the opening session Sir Henry Tizard indicated that the Government would listen sympathetically to requests for funds to carry out the recommendations of the Conference, and during the closing session Dr. D. W. Bronk, of the American National Academy of Sciences, said that financial support would also be forthcoming from the other side of the Atlantic. Certainly funds will be necessary, since the first recommendation calls for the setting up of a committee, representative of the interests present at the Conference, and charged with the primary task of carrying out operational research into the question of how scientific literature is used. The preliminary results of an investigation by Professor Bernal into the reading habits of some 200 scientists were before the Conference, and they showed clearly that much more could usefully be done on similar lines.

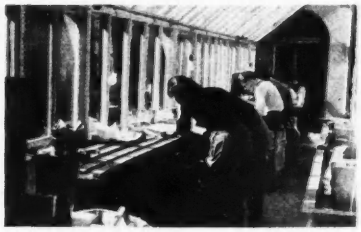
The work of the Conference was divided into four sections: (I) publishing and distribution of scientific papers; (II) abstracting services; (III) indexing and library services; (IV) reviews and annual reports. In each section a large number of apparently minor detailed recommendations were made which, taken together, will result in a substantial reduction in the number of man-hours wasted in searches of scientific literature. Of the major recommendations, three may be mentioned. In Section I, N. W. Pirie's proposal that papers should be published at two different levels of completeness is to be referred to committees of editors of journals covering cognate sciences. The intention is that a précis of the paper, much fuller than the usual abstract, should be published simultaneously in a special précis journal, thus enabling the scientist to keep in touch with fields related to his own without having to read all the papers in full, or to skip through them inefficiently. Such a scheme will be of special value to Commonwealth scientists with no easy access to libraries.

In Section II the eminently reasonable proposal was made that abstracting agencies should be provided with factual summaries of papers by the editors of scientific journals at as early a stage in the publication of the paper as possible. If adopted generally this may prove to be the most useful recommendation made by the Conference.

Section III found that very much more research was required into systems of indexing and classifying scientific knowledge before full advantage could be taken of the many ingenious mechanical and electronic sorting devices which are available. It therefore recommended the formation of a standing committee to initiate such research.

While it is too early yet to assess the practical results of the Conference in terms of accomplished reforms, so many of which depend on co-operation between bodies not always distinguished for their enthusiasm for mutual aid, there is no doubt that the prospects have been much improved by it.





The new Field Centre, opened at Dale Fort by the Council for the Promotion of Field Studies, offers great scope for students and amateur naturalists, particularly those interested in birds and marine biology. (*Left*).—The court-yard of Dale Fort. *Centre*: The Warden, Mr. John Barrett (on right), and students collecting on the Slipway Beach below the Fort. The village of Dale lies at the head of the bay. (*Right*).—Students at work in the improvised laboratory in one of the glasshouses. (*Photographs copyright by the author.*)

# Field Days at Dale Fort

R. DENISON PURCHON, Ph.D.

It is many years since R. M. Lockley first occupied the island of Skokholm off St. Ann's Head, at the south-western extremity of Pembrokeshire. The bird observatory that he developed there was visited annually by large numbers of ornithologists and other naturalists, and soon became well known throughout the country, not only on account of the ornithological work carried out on the island, but also for the effect it had in focusing attention upon the desirability for the protection of the islands of Pembrokeshire and the preservation of the large populations of sea birds which they support. The novels of R. M. Lockley, too, emphasised the attractions and difficulties of island life, and he outlined in them the nature and the natural history of the islands and coast of Pembrokeshire.

The West Wales Field Society has taken a prominent part in the preservation of these amenities, and in 1946 the Society rented Skomer Island for one year, maintaining a shore reception station at Martin's Haven and accommodating visiting naturalists on the island. I had stayed for some weeks on Skokholm on two occasions before the war and was very glad of the opportunity of spending a few days on Skomer in April 1946 to estimate the prospects for field work in marine biology there.

At the time, Mr. R. Bassindale of the Department of Zoology at Bristol University was running a course in marine biology on Skomer for a party of undergraduates. Some very interesting material was collected in spite of the limitations imposed by the small areas of accessible beach. Clearly, however, an island was not the most desirable base for marine biological 'field work'. In the first place, the great exposure of this particular stretch of coast and the powerful tidal currents around the islands would make any boat work unduly hazardous, and a visiting party might easily wait a week or more before being able to cross over to the island. Such a delay is particularly serious for the marine biologist whose activities are centred on the few days of spring tides.

Everyone who has read the works of Philip Henry Gosse or Thomas Hincks will have been struck by the frequent references to Tenby which was a famous collecting ground for marine biologists in the nineteenth century. Although the strip of coast in the vicinity of St. Ann's Head is little known to marine biologists, one would expect it to support a fauna that would reflect the local variations in exposure to and protection from the open Atlantic.

From the point of view of class work in marine biology a Field Centre should be a shore station, easily accessible by road; there should be a safe anchorage for the station's boat; the station should be near a sheltered bay where dredge, trawl and tow-net could be operated whenever desired, and there should be a wide variety of shore environment close at hand.

These conditions are all met at Dale Fort, a Field Centre which has been opened this year by the Council for the Promotion of Field Studies. I was fortunate in being permitted to take a party of undergraduates to Dale Fort at Easter.

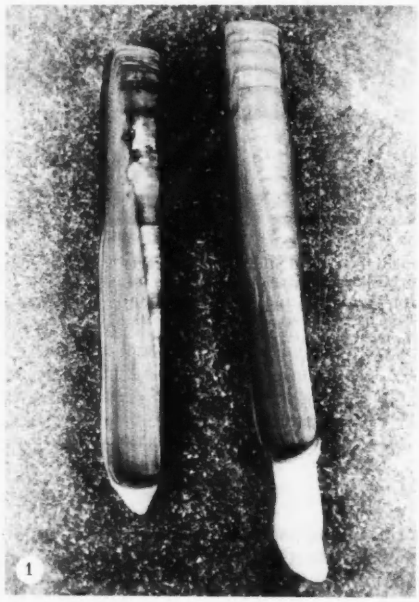
The Fort was built nearly a century ago to offer protection to the mouth of Milford Haven. Comparatively recently, glass houses were built along one side of the courtyard and these serve well as temporary laboratories. The permanent laboratories will be sited elsewhere in order to provide the cool conditions necessary for the study of living marine organisms. The Fort has at present a reserve of rooms for accommodation, domestic offices, library, museum, laboratory, common room and so on. Being very strongly built and having a flat roof, it is susceptible of almost any degree of development for special purposes; for example, a large laboratory with maximum window space could be provided.

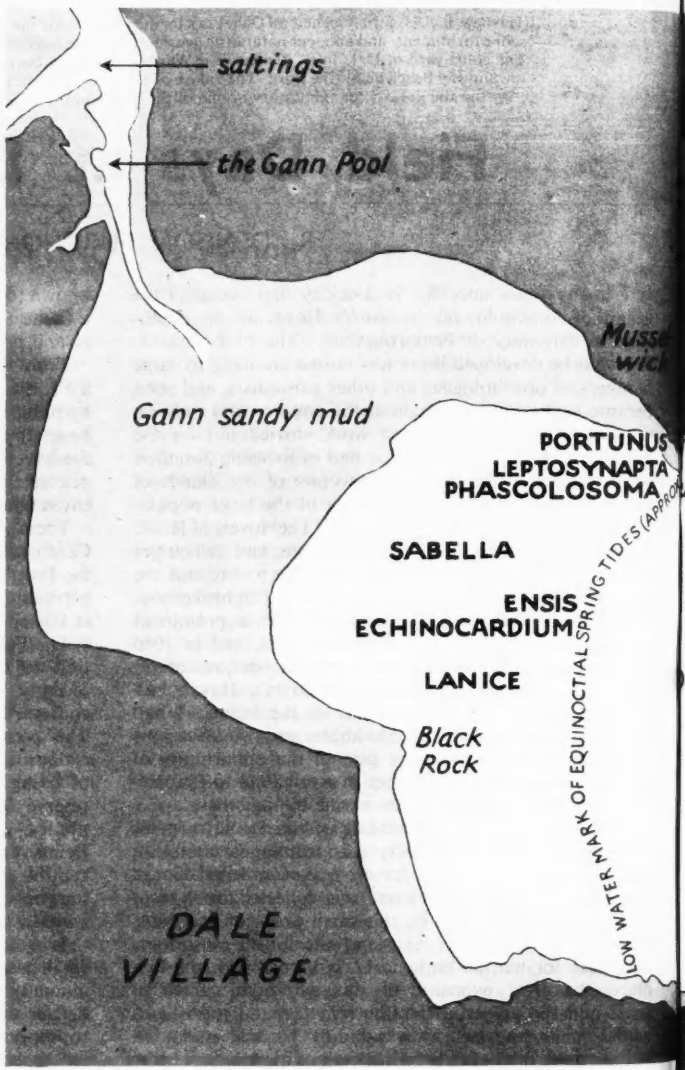
It is often argued that heavy collecting year by year on a small area of beach does no harm, for re-population occurs annually from breeding stocks on adjacent beaches or in deeper water. This is an argument that I find impossible to support. On an untouched beach certain characteristic species may be sufficiently abundant to be seen in their normal living conditions by every student. Any serious reduction in their population will mean that only a few specimens are found, probably only by the most experienced collector. Many students will, therefore, only see that particular interesting and characteristic animal in the laboratory at the end of the day.

The heaviest collecting is inevitably in the immediate vicinity of a field station. Dale Bay is quite small and it

# A Selection of th

1. *Ensis (Solen) siliqua*, the Razor-shell.
2. *Corystes cassivelaunus*, the Masked Crab.
3. *Portunus puber*, the Velvet Swimming Cra
4. *Echinocardium cordatum*, a Heart-urchin.
6. *Phascolosoma elongatum*, a worm with commensal bivalves (*Myselia*).





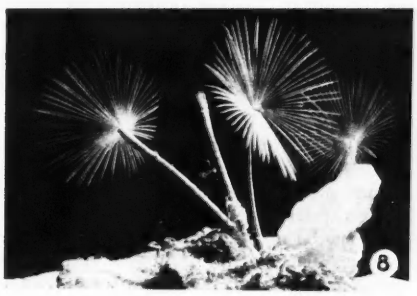
# Dale Bay Fauna

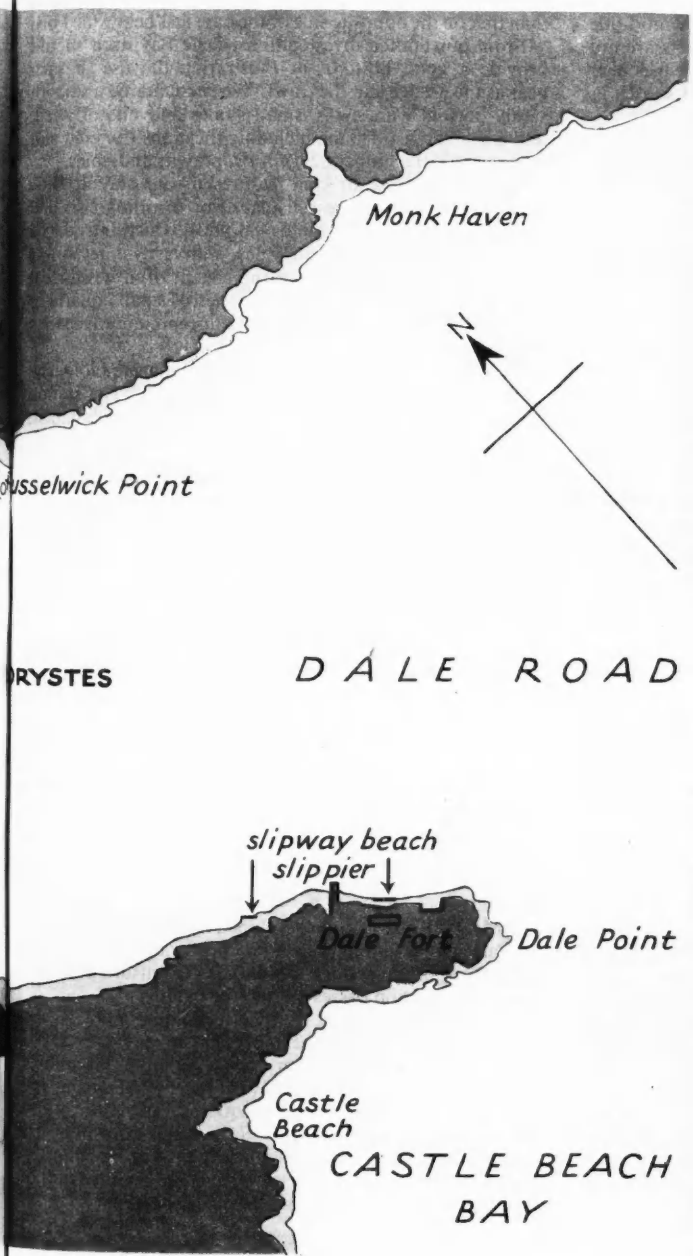
5. *Leptosynapta inhaerens*, a burrowing sea-cucumber. As commonly happens, the fragile body has broken in two. On the front is crawling a commensal bivalve (*Devonia perrieri*).

6. *Lanice conchilega*, a worm that builds frill-tubes of sand.

7. *Sabella pavonina*, the Peacock Worm.

Photographs copyright by Douglas P. Wilson.



contains a sufficient variety of habitats and sufficiently rich faunas to satisfy a short course in marine biology. Obviously the greatest care must be taken not to admit too many students each year, not to collect many specimens of the rarer species, and not to allow damage to breeding populations by leaving boulders overturned.

Immediately below the Fort the Slipway Beach, as we called it, is very suitable for the first day's work. Zonation is well displayed by the seaweeds, barnacles and gastropods, though the growths of wracks (Fucaceae) below mid-tide level are rather ragged and weak. Large boulders are not abundant nor are there any overhanging rock ledges near low-water mark. Consequently the fauna is not so rich as to bewilder the beginner.

At the head of the bay, on the far side of the village of Dale, there is a broad expanse, the 'Gann muddy sand'. Walking down through this towards low-water mark, one passes through a succession of zones which we did not have time to investigate closely. One region is dominated by the lugworm (*Arenicola*), and others by the fanworm *Sabella*, and the worms *Lanice* or *Owenia*.

At the low-water mark of equinoctial spring tides there is, in the centre of the bay, a broad expanse of clean sand, dominated by the Razor-shell (*Ensis*); here many characteristic species were found, such as the rare burrowing anemone *Peachia*, the sandworm *Pectinaria*, the bivalve *Cyprina* and the heart-urchin *Echinocardium*.

Below Musselwick there is a rich zone of large boulders standing on muddy gravel. The boulders we found to support an abundant fauna and under each was a velvet fiddler crab (*Portunus puber*) and either a Rockling or a Conger. The muddy gravel, however, held the greatest surprises, for the worm *Phascolosoma* and the burrowing 'sea-cucumber' *Leptosynapta* were both quite common.

Further round the bay, at Musselwick Point, large boulders, rock ledges and rock pools extend right down to low-water mark and consequently the fauna is far richer than that on the opposite side of the bay, just below the Fort.

From our limited investigations, Dale Bay itself should provide a good bottom for illustrating the use of such gear as the dredge and the trawl. We encountered a smooth sandy bottom with shells, small stones and bits of weed, and a characteristic fauna including the crabs *Corystes* and *Macropodia*, the limpet *Calyptraea*, prawns and soles.

One of the most striking features of our stay at Dale Fort was the wide interest displayed by ornithologists and botanists in our marine biological finds, which introduced them, of course, to an entirely new and vastly entertaining realm of natural history. For the benefit of all visitors, it should be possible to establish a series of small aquaria at the Fort, in which to keep a small but representative stock of the local marine fauna.

I have attempted to describe only the marine biological attractions of the Field Centre at Dale Fort. The station is equally attractive from the point of view of the botanist, the ornithologist or the archaeologist.

## ARTIFICIAL INSEMINATION OF BEES

A QUEEN honey bee normally mates once, twice or even as many as three times before she commences to lay her first eggs, and although she may live for three or four years and produce between one hundred and fifty and two hundred thousand offspring each year, she never mates again after she has once commenced to lay. In good weather a virgin queen makes her first short flights, during which she learns the location of her hive relative to neighbouring objects in the apiary, when she is three or four days old. She is ready to mate with any drone she may meet whilst on the wing from about her fifth day of life onwards. Once she has mated and her sexual desires have been satisfied she settles down in her hive and becomes a highly efficient egg-laying machine, producing all the worker bees in her colony from eggs fertilised by sperm from her spermathecal store which became filled when she mated.

Unfortunately few people have seen a queen and drone in coitus so that we know practically nothing about their behaviour at this time except that copulation occurs somewhere outside the hive and out of man's control.

For many years past beekeepers have tried to arrange the mating of a given queen with one or more of a number of selected drones by such methods as keeping them in confinement in glass houses, tethering the queen, etc., but their efforts have always failed. Even artificial insemination of queens was tried as long ago as 1850, but it was not until about 1926, when Dr. Lloyd Watson demonstrated that this operation was possible, that anybody succeeded in inseminating a queen bee with a microsyringe. The Watson technique, despite certain improvements made not only by Dr. Watson himself, who continued to work on this subject until his death earlier this year, but also by Mr. W. J. Nolan and others, did not lead to the progress anticipated and was only of value in a very limited way for genetical and similar studies. It was indeed a most imperfect technique. Some four or five years ago, however, another American research worker, Dr. H. Laidlaw, made a detailed study of the genitalia of the queen honey bee and discovered the presence of a membranous fold in the floor of the vagina which, acting as a valve, serves to close the opening of the median oviduct in the living queen. This fold he called the 'valve-fold'. It immediately became apparent that in order to inseminate a queen bee successfully it is necessary to inject the semen of the drone past the valve-fold into the median oviduct and thus into the paired oviducts, from whence the sperm can migrate into the sperm storage organ, the spermatheca. Two U.S. workers, Dr. O. Mackensen and Mr. W. Roberts, soon developed a technique to depress the queen's valve-fold with a fine probe and, by inserting the tip of micro-syringe beyond it, to ensure that the semen on injection passes up into the oviducts.

Further development of this technique, notably the artificial 'ageing' of the queen bee, has made it a practical proposition for the worker, given suitable laboratory facilities, to inseminate queens with semen taken from any desirable drones and to cause the queens to lay as early and as well as naturally mated ones. Such queens are perfectly capable of heading the largest honey-producing colonies. Thus at last the key to the development and maintenance of improved strains of bees has been discovered.

COLIN G. BUTLER.

INSTALLING THE MIRROR OF

# The Commonwealth's Largest Telescope

DAVID S. EVANS, M.A., Ph.D.

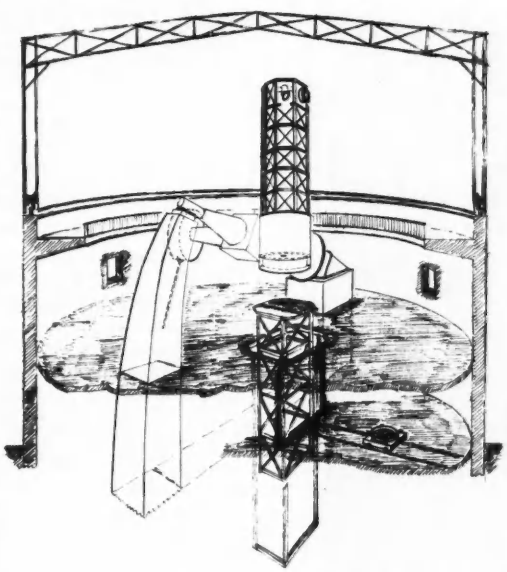
THE Radcliffe Observatory was transferred from Oxford to Pretoria some ten years ago. The plans of the Director of the Observatory, Dr. H. Knox-Shaw, called for a reflecting telescope of 74 inches aperture, the largest in the Southern Hemisphere. An unfortunate series of mishaps during the casting of the disc of fused quartz for the mirror in the United States delayed its delivery to England where it was to be ground and figured by Sir Howard Grubb, Parsons and Co., constructors of the telescope. The war then intervened and it was only in April of this year, thirteen years after the letting of the contracts, that the mirror was finally delivered to the Observatory. In the meantime a cast iron weight of 5000 lb. had been used as a dummy to balance the telescope mounting, which had already been erected before the war, and enabled this with its driving clock and circles to be used as a support for small cameras and other research equipment. These arrangements were, however, only makeshift, and the real work of the Observatory at Pretoria will only begin when final adjustments are completed.

The telescope tube, some thirty feet long and eight feet in diameter consists mainly of an open lattice work, on the lower end of which is a closed section with the detachable cell in which the mirror is carried. The main polar axis of the telescope is formed into a large cube at the centre. This carries a cross axis (the declination axis) on which the tube is actually mounted. A counterweight on the other end of this axis balances the telescope as far as movement round the polar axis is concerned, and arrangements are also provided for fore and aft balancing in the tube about the declination axis.

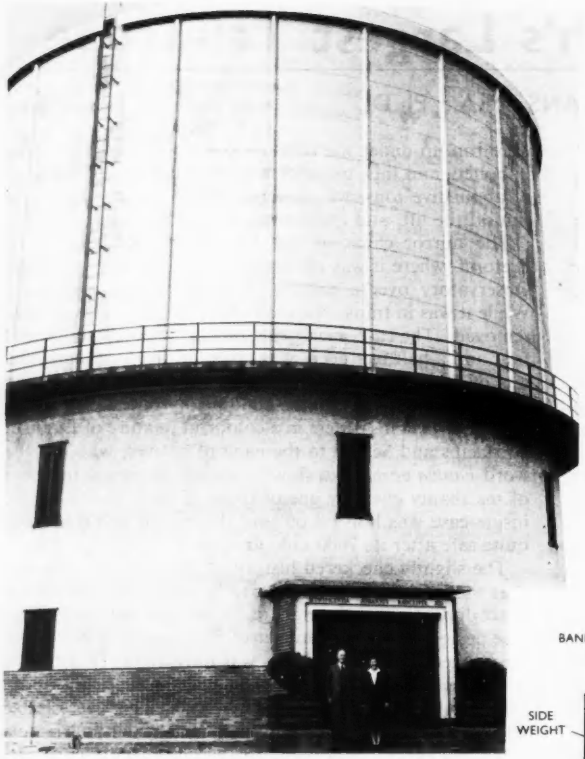
As a first step the cell and the dummy mirror had to be removed. The tube was turned to the zenith, a prop was put under the counterweight to take the out-of-balance load which would be set up when the cell was removed, and movement round the declination axis was prevented by wiring the tube up to the roof-members with cables. A lift, with a run from the ground floor up to the base of the telescope, about twelve feet above the observing floor, is provided. This has a set of rails continuous with a set on the ground floor, on which runs a small, heavy truck, topped by a ring member capable of a small movement in all directions for centering purposes. The lift and truck were run up under the cell, to take the load, the cell was unbolted, and this, together with the dummy, a total load of about five tons, was lowered to the ground floor and run off the lift, and the dummy mirror removed.

The mirror came by sea to Durban and by rail to Pretoria, where it was off-loaded for its journey up to the Observatory over a narrow, twisting, steep gravel road. While it was in transit the main doors of the building were removed. The case, measuring nine feet square and about four and a half feet deep, was taken off the lorry with two sets of sheer legs. This outer case was then removed and the inner case rolled into the building on rollers. The rigger in charge gave his orders in a colourful mixture of English, Afrikaans and Sesuto to the gang of natives, who, on the word *hamba gashly* (go slowly) heaved in unison to a sort of sea shanty given by one of them. Finally the lid of the inside case was hoisted off and the mirror could be seen quite safe after its 7000 mile journey.

The slightly checkered history of the mirror had meant that the mounting design had to be completed before the exact dimensions and weight of the mirror could be known. The designed overall diameter of 76 inches was, of course, unchanged, but the thickness was only about 11 inches at the edge instead of 13 and the weight (actually about 3600 lb.) was correspondingly reduced. This necessitated certain changes in the mounting. The mounting system is complicated in design, but has the simple purpose of providing a mechanical flotation system which exactly balances the load however the telescope is tilted. The vertical load is carried on three large screws, each of which carries on a ball joint a large triangular casting. At the end of each of the three arms of each of these castings is a cork pad carried on a ball race mounted on the casting by means of a ball joint. These nine pads carry and distribute the vertical load of the mirror, and the location of the support components is secured by means of a series of spring plungers. The total effect is to provide always a pure thrust and never any drag which, experience has shown, may distort the figure of the front-reflecting face of the mirror. Round the mirror is fitted a flexible band, carrying brackets which fit over the shanks of 18 lead weights mounted on the sides of the cell on universal joints. When the mirror is tipped these brackets bear on the weights,

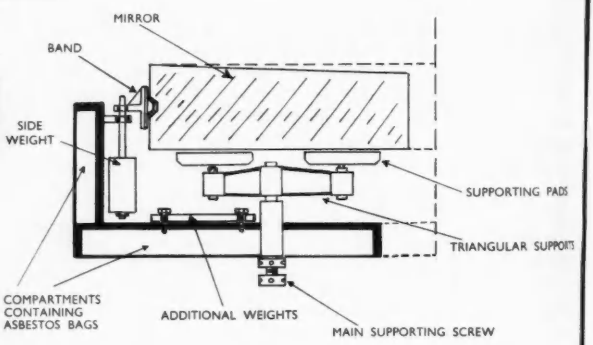


General view of telescope showing the 76-in. mirror in its cell, the secondary mirror at the top of the telescope tube, and the prop under counterweight. The lift is half raised and the truck is on the ground floor.



General view of the turret.

Opening the packing case in which the mirror was transported.



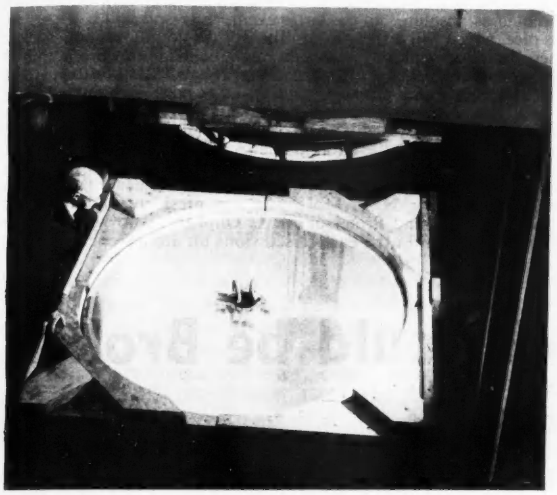

Section through half of mirror and support system. The spring plungers controlling movement of the triangular supports and supporting pads are not shown.

The telescope tube, wired to roof members. The secondary mirror holder is visible.

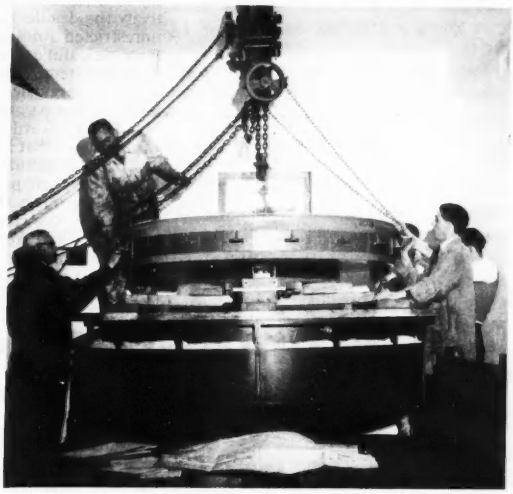
and these relieve the sideways stress, coming into action always just to the extent needed to balance the load. The mirror is actually located by means of pins, three fixed and three sprung, which screw into the side of the cell.

All these components were delivered at the same time as the mirror. The reduced weight necessitated fitting extra weight in the form of thick steel plates into the cell, and the reduction of the lever arms of the side balance weights. Work also had to be done on fitting the supports for the spring plungers. A number of amateur astronomers, several research students from the University of the Witwatersrand, and a distinguished visiting astronomer lent valuable aid in this work. All this took two or three weeks, and the burnishing of the mirror—removal of the bloom from the silver surface with jeweller's rouge—occupied some time.

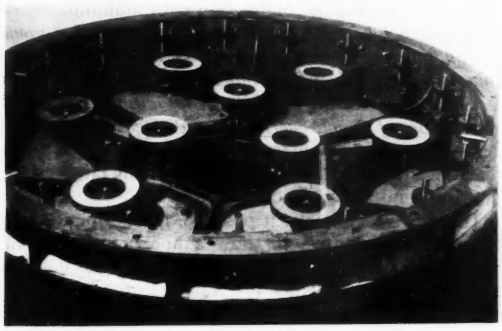
The actual installation, carried out before an interested crowd of spectators, including reporters (who were at one



The packing case has been opened. Dr. H. Knox-Shaw, the Observatory's director, inspects the mirror which is protected by a cover of Perspex.



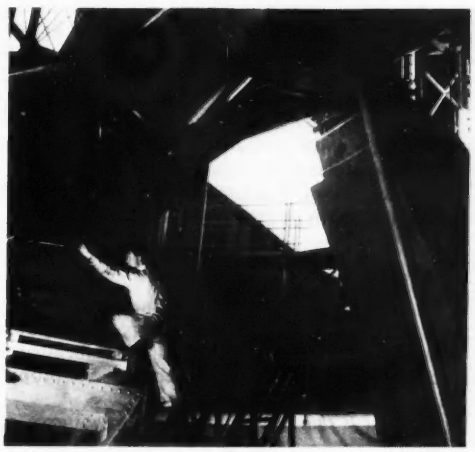
Fitting the band before lowering the mirror into its cell.



This photograph shows the arrangement of pads which support the mirror in its cell.

Raising the mirror in its cell.

stage dragooned into a gang for the handling of the mirror case) and the news-reel cameras, occupied only a short time. In only two and a half hours the mirror was hoisted into its cell, the band fitted, and the whole elevated and bolted on to the mirror cell. Thereafter a good deal of pedestrian hard work had to be done. The asbestos insulating pads for shielding the mirror from temperature extremes had to be fitted into the back of the cell and the cover plates put on. Then the secondary mirror holder, a fairly massive casting, had to be hoisted out and the secondary mirror fitted. The tricky job of balancing the telescope had to be completed, and then the alignment of the optical components had to be made exact. All these tasks take a great deal of time: they constitute the unspectacular process of 'getting the bugs out' as the Americans would say. A host of enquirers who imagined that once the main mirror was in, the telescope would be ready for use (and open to visitors) had to be disabused of this notion. But at last the time was in sight, when effective observations would begin and a great scientific project would start to pay observational dividends.



The mirror in position. Dr. Evans puts the finishing touches.

THE Atomic Energy Commission has reached a dead end. It might make a new start and try to discover a workable basis for an effective scheme of atomic energy control; alternatively the deadlock is accepted as absolute. In the latter event, the result will be either an unrestricted atomic arms race, which will direct most of the world's uranium supplies away from peaceful atomic energy development, or an attempt might be made to work a limited control scheme designed to bring the benefits of international collaboration in the field of atomic energy development for peaceful purposes as well as to give greater collective security against attack by atomic weapons. The latter course is advocated by Mr. E. M. Friedwald towards the end of this article, the first part of which is devoted to a discussion of the stages that led up to the deadlock in the Atomic Energy Commission.

Copies of this article were circulated to a number of atomic scientists, with an invitation to contribute their personal views as to what might be done to break the deadlock. In this issue we publish the ideas of Professor N. F. Mott, who was president of the Atomic Scientists' Association for two years, and Professor M. L. Oliphant, who was technical adviser to the Australian Government in the early discussions on atomic energy control at Lake Success.

# The Atomic Deadlock Could be Broken

E. M. FRIEDWALD

ON the morrow of Hiroshima the world was told that it had a breathing space of four or five years in which to adjust its political institutions to the realities of the new-born Atomic Age—or else to drift towards global disaster. A few months later, on November 15, 1945, the President of the United States and the Prime Ministers of the United Kingdom and of Canada, after meeting at Washington to consider the international implications of the release of atomic energy, issued a joint declaration recommending the setting up of a system of international control. Six weeks later, at the conclusion of the Moscow Conference of the Foreign Ministers, on December 27, 1945, the Big Four agreed to establish, under the authority of the Security Council, a commission composed of the members of the Security Council with the addition of Canada, in order to inquire into the problem of international control of atomic energy.

The Atomic Energy Commission of the United Nations actually came into being on January 24, 1946, and held its first meeting on June 14, 1946. On May 17, 1948, after nearly two years of discussion and 220 meetings, this Commission had to admit that it had reached a deadlock and, by nine votes to two (the two dissentients being the Soviet Union and the Ukraine), decided to recommend to the Security Council that its activities should now be suspended. Three years after Hiroshima, the world is no more prepared to meet the challenge of the Atomic Age than it was on August 6, 1945. In fact, it is farther from it, for in those three years it has lost much of the hope which the atomic challenge—perhaps the greatest that has ever faced mankind—aroused in the hearts of men of goodwill.

## The Lilienthal Scheme

The starting point in the international control of atomic energy is the report of the State Department published in March, 1946, usually known as the Lilienthal Report, occasionally as the Acheson Report.* Its proposals are based upon two key facts.

*The first is that uranium is the only substance occurring with any significant abundance in nature which, in the present state of knowledge, is indispensable for the production of atomic energy.* The only other naturally occurring element which lends itself to the generation of atomic energy is thorium—but only in conjunction with uranium.

*The second key fact is that the nuclear fuels (uranium and plutonium) can be denatured, and thus rendered unsuitable for the production of atomic explosives, while still retaining most of their effectiveness so far as peaceful applications of atomic energy are concerned.* To remove the denaturant is, in the present state of technology, a major scientific and industrial operation involving large factories that could not be easily concealed.

These two facts make it possible, in the opinion of the Lilienthal Committee, to draw a line between activities in the atomic field which must be considered as dangerous to peace and those which are 'safe'. In the first category the report placed the mining of deposits of uranium and thorium minerals, the operation of the plants manufacturing nuclear fuels in concentrated form from these minerals, and naturally the production of atomic explosives. All other activities can be considered as safe in the present state of science and technology. The proposals of the Lilienthal Committee were that all the dangerous activities be taken over by an international authority, the Atomic Development Authority (A.D.A.), and that the 'safe' activities be left under national control. The Authority would establish its plants so as to preserve the strategic equilibrium between nations, and the nuclear fuels would be immediately denatured and delivered to individual nations for industrial and other peaceful purposes. The Authority would also have the right to inspect each country to insure that no dangerous activities were being carried on clandestinely, such as the mining of uranium and thorium, or the regeneration of denatured materials. As these activities would involve major operations, they could not easily escape detection in a thorough inspection.

Nor, under the scheme, could a nation gain an advantage over others by seizing the plants or deposits situated on its territory. For as nuclear fuels would be denatured as soon as produced, and distributed so as not to leave any large stocks, a transgressor could gain no immediate advantage by seizing the Authority's plant. And it would

* Acheson was Secretary of State at the time and responsible for appointing the committee of five which, under Lilienthal's chairmanship, produced the report.

take him at least a year to produce any dangerous amount of atomic explosives. But by his action he would have given an unmistakable danger signal to the rest of the world which would thus be afforded time to take appropriate measures. In other words, the scheme would give all nations an assurance of security from a sudden and annihilating blow.

The Lilienthal Report made clear, however, that its plan for international control might have to be adjusted to meet possible new developments in the field of atomic energy. That is why it insisted that the Authority should lead in atomic research so as to be the first to know where the line between dangerous and safe activities should be drawn. If, for instance, the regeneration of denatured materials should, through the progress of technology, become a more simple and easily concealable operation, the activities and scope of control of the Authority would obviously have to be enlarged. Thus the whole scheme took on the aspect of world government in embryo. For, as the progress of our scientific civilisation made world integration more and more necessary, the Authority would gradually extend its activities over an ever-widening field, and assume little by little the function of a world government.

The recommendations of the Lilienthal Report form the core of the proposals for a world control scheme (the Baruch proposals) put forward by the United States to the Atomic Energy Commission of the United Nations. They can be briefly summarised as follows:

1. Establishment of an international authority to be in sole control of all operations classed as dangerous, and to have power to deal with new developments as they arise.
2. The Authority to license, control and inspect all other atomic energy activities left under national control.
3. The power of veto not to apply either to the day-to-day work of the Authority or to the punishment of transgressors.
4. The control scheme to be put into effect in successive stages, the United States gradually relinquishing, to the extent required by each stage, national control of its atomic activities.

This is the essence of the Baruch plan. Of the 17 nations which have sat on the Atomic Energy Commission since it was formed, all but three have approved it. The three dissentients have been the Soviet Union, Poland, and the Ukraine.

Russian objections to the Baruch plan have been many and varied, but have finally crystallised into three main points.

The first concerns the power of veto in relation to the punishment of transgressors. The Soviet Union, while agreeing to waive the right of veto where the day-to-day activities of the Authority were concerned, insisted on its retention in the case of sanctions against a transgressor. Now if the control scheme is to work effectively, there can be no veto to provide a legal loop-hole for a violator. And it is not difficult to visualise a situation in which a violator, by the exercise of his veto right, could so confuse world opinion as to cause a fatal delay. The punishment ought to be immediate and automatic for, as Mr. Baruch said, "the bomb does not wait upon debate; to delay may be to die".

Yet it may be argued that the main purpose of the control scheme is to ensure against the danger of a sudden and overwhelming blow, to provide a warning signal and a respite in which to take appropriate action. Once the warning was given, the initiative would lie ultimately with individual nations, particularly with the Great Powers. And while an astute exploitation of the veto right might easily confuse the issue and leave room for side-stepping, it need not necessarily do so. If public opinion in the leading nations is fully aware of the issues at stake, if its instinct of self-preservation is fully aroused, the restraining effect of the veto would cut no ice with the dictates of commonsense and self-preservation. And if public opinion is misinformed, apathetic and bemused by wishful thinking, then even without the veto it could find enough loop-holes to evade the issue. In short, if the abolition of the veto had been the only obstacle to agreement, it might have been worth while to let the veto stand for the time being and postpone the solution of this thorny problem until passions and suspicion had died down. But this was far from being the only point of disagreement between Russia and the West.

Another Russian objection—and one which is more difficult to meet—is that concerning the step-by-step procedure for the setting up of the control scheme. This procedure would naturally mean the maintenance of the American monopoly of atomic weapons until the final stages of the world control scheme had been reached. The Soviet Union has insisted that, before any Authority is set up and regardless of arrangements for control, inspection etc., all nations should outlaw atomic bombs and destroy all existing stocks of atomic weapons under international supervision.

Now while the step-by-step procedure would undoubtedly mean the maintenance of the American monopoly for a few more years until the completion of the control scheme, the fact remains that, in the absence of any control scheme, the United States is likely to retain its monopoly for a much longer period, and to maintain a comfortable lead for an even longer time. Had Russia accepted the Baruch plan two years ago, the American monopoly would by now be nearing its end. As it is, this monopoly is likely to be maintained for several years more. Moreover, it is surely preposterous to demand that American plants should be inspected at once because their existence is no secret, but that hypothetical developments in other parts of the world need not be inspected yet, presumably because little is known about them. And it is to tax rather heavily American goodwill and credulity to ask the United States to give up its lead in the atomic field without any reasonable assurance that no other country will one day possess atomic bombs while their originator has none.

But even this second objection, difficult as it would be to meet, fades into insignificance beside the third and fundamental Russian objection to atomic control: the Soviet Union is categorically opposed to international ownership of deposits or plants, or to supra-national management of them, to unlimited access to atomic plants for inspection, to aerial surveys by the Authority, in short, to anything which would make the control effective and real. The Soviet Union takes its stand on the principle of

absolute national sovereignty and is not prepared to relinquish any part of it in any cause. But such an attitude constitutes an obstacle as insuperable as it is fundamental. For any effective system of international control of atomic energy is incompatible with absolute national sovereignty.

No doubt, the Soviet Union has agreed to the principle of inspection, but has made it clear that the inspection is to be a limited one. Now the Lilienthal Report was at pains to emphasise that, as far as the dangerous operations were concerned, the degree of inspection and supervision needed for an effective control of plants operated on a national basis would involve so much interference, such a persistent challenge to the good faith of nations and of individuals, that it would be simply unworkable. And even the most thorough inspection could not guard against leakages and diversion of atomic explosives under the cloak of process losses. That is why the Report insisted on the absolute necessity of removing the dangerous operations from national control and handing them over to the sole management of a supra-national authority. This would no doubt mean sacrificing a certain measure of national sovereignty. But such a sacrifice represents the price of survival in the atomic age.

## A.D.A. minus Russia

It is clear that as long as the Soviet Union maintains its uncompromising stand on the principle of absolute national sovereignty there is no possibility of establishing any really effective scheme for control of atomic energy which would embrace the whole world. And this being so, the rest of the world seems to have resigned itself to drifting, to letting things take their course and hoping for the best. Not that there is any hope of the United States retaining its monopoly for more than a few years. At the beginning of 1948, President Truman's Air Policy Commission gave it as their opinion that on January 1, 1953, America would face A-Day—the day when foreign countries would almost certainly possess atomic weapons and effective long-range guided missiles in quantity. Once this stage has been reached, the establishment of an effective control scheme will, for technical as well as political reasons, be infinitely more difficult than it is now. And the hope that some vague and ill-defined fear of reprisals would be enough to prevent any aggressor from using atomic weapons goes against the accumulated experience of history. No amount of wishful thinking can alter the fact that to drift is, in all probability, to drift towards global disaster.

What then is the alternative?

Surely if, in the absence of Russian co-operation, it is impossible to establish a control system which would prevent the manufacture of atomic weapons, the next best thing would be to devise a system which would effectively prevent their use; and this can be done without Russian co-operation. In other words, the five-sixths of the world which recognises the imperative need for a certain measure of world integration should go ahead without Russia. Naturally a control scheme excluding the 300 million people of the Russian bloc could not aim at preventing atomic armaments: on the contrary, it must aim at producing the most advanced and effective atomic weapons, at distributing them according to strategic necessities, at holding itself ready for instant action—in short, at building up such an overwhelming power as to confront any potential aggressor with the certainty of swift annihilation. If the Authority maintains plants and stocks of atomic weapons in western Europe, the Middle East, India, China, Alaska, in a word, everywhere within its jurisdiction, if it is ready to act at a moment's notice, no aggressor could hope to escape total destruction. And wars do not start unless an aggressor has reason to believe that he has something to gain without risking too much.

Naturally, if such a scheme is to succeed, the Authority would have to be something very different from the United Nations. It would have to be a truly supra-national authority, able to make its own decisions without any reference to purely national interests, and endowed with the authority—and the power—to enforce them. Herein undoubtedly lies the biggest single obstacle to the realisation of such a scheme, for even the nations in favour of an effective atomic control would not lightly agree to merge an appreciable part of their sovereignty into a supra-national body. But they have explicitly recognised the need to take this fateful step, and there is no reason why they should change their minds. Once this major obstacle has been overcome, the others present no great difficulty.

Indeed, what are the other objections to an atomic control scheme without Russia?

It is often argued in the United States that the sharing of atomic knowledge with nationals of other countries participating in the scheme would make it easier for Russia to learn whatever there remains to be learned of the secrets of the atom. But this contention ignores the fact that the real secret is not something which can be easily passed over on a slip of paper. It lies rather in the accumulated experience and vast working knowledge of a large body of scientists and technologists thoroughly conversant with all the tricks of scientific technique, all of which is the natural appurtenance of a nation accounting for nearly three-quarters of the world's industry. To gain any real advantages from 'atom spying', Russia would have to get hold of a large number of foreign scientists and technologists—and the right ones at that. Moreover, the primary aim of the scheme would be to prevent the use, not the manufacture, of atomic weapons.

Another and more serious objection is that a country in which the Authority has built plants and stocks might turn communist and seize them. The answer to such a contingency is that the Authority's sites would have extraterritorial rights, and that any attempt by any country to seize them would amount to aggression and as such be liable to full retribution. The danger of seizure might be minimised by some device whereby plant and stocks could in an emergency be destroyed at a moment's notice.

These are objections of a technical nature. But there is also another argument, a political one. It is said that as any atomic alliance excluding Russia must, by the logic of facts, be potentially of an anti-Russian character, an atomic control scheme excluding the Soviet Union would permanently split East from West and destroy what slender chance remains of a rapprochement.

Even if this were true, it would still be an infinitely better solution than the one which consists in drifting and doing nothing. For this way lies atomic chaos—on the dawn of A-Day, and the likelihood of a fully fledged atomic war to follow sooner or later.

But is it so certain that starting without Russia would permanently split East from West?

So far the Soviet Union has determinedly opposed any control scheme which would stand a reasonable chance of fulfilling its functions effectively. And there is every reason to believe that it will continue to maintain its opposition as long as it is led to believe that by its mere abstention it can frustrate any initiative on the part of the West in establishing some form of atomic order. But if the West decided to go ahead without Russia, if it succeeded, as it certainly would, in binding together the greater part of the world in the control of the atom, it would create an atomic alliance so overwhelmingly powerful that its mere existence would constitute a permanent threat to any nation standing outside it. How long could Russia, which has so clearly shown her fear of any kind of bloc, afford to stand aside from such an overwhelmingly powerful combination? The political realism which runs like a thread throughout Russian history encourages the view that it would not be very long. In fact, to start without Russia may be the only peaceful way of getting her co-operation.

# AN ATOMIC ALLIANCE HOLDS NO SECURITY FOR BRITAIN

By PROFESSOR N. F. MOTT, F.R.S.

MR. FRIEDWALD'S article calls for a world-wide alliance, which, acting through a supra-national authority, would deter the Russian Government from any aggressive act by the threat of overwhelming attack with atomic weapons. Mr. Friedwald calls his authority an A.D.A. without Russia, but this in my view is a most misleading designation. The purpose of the A.D.A., as envisaged originally in the Lilienthal report, was to develop atomic energy for peaceful purposes all over the world, under a scheme of international ownership and control which would ensure that the facilities built up were not diverted to the production of weapons. Mr. Friedwald, on the other hand, proposes that the countries outside the Russian orbit should produce atomic bombs to the limit of their capacity; and he is certainly wrong in thinking that an authority set up for this purpose would erect plant or accumulate bombs in Europe or in the Middle East. Military considerations would ensure, as in the last war, that manufacturing plant should be built in the relative safety of North America, whence if need arose bombs could be rapidly transported by air to the forward bases. Apart from the provision of these bases and of armies to guard them, the only specifically 'atomic' contribution which Europe could make to the alliance would be the services of her scientists, who, as in the last war, could co-operate with their American colleagues in the production of these weapons. Even if plant were erected in Europe, the number of bombs which could be produced there would be insignificant compared with that in the United States.

A loose military alliance between Western Europe and the United States seems now to be taking shape, and apart from the implication, with which I disagree, that such an alliance would be strengthened by the sharing of atomic development, Mr. Friedwald's article recommends little beyond the building up of the alliance and an open decision to use atomic weapons in case of war. His article, however, does not discuss the real problems involved in this policy. These seem to me to be as follows. In Western Europe the governments, supported by much of the population, wish to be free from the fear that the communist parties in their countries can, in the last resort and at an appropriate time, count on armed Russian support. In this they have the sympathy of the United States, and, with American support, in course of time it may be possible to build up in Europe land forces which can hold Western Europe against the Red Army. This, however, cannot be done quickly, and an alternative policy which appeals to influential circles in the United States as quicker, cheaper in manpower and more effective, is to rely on the threat of destruction of Russian cities by a large strategic air force. This policy relies on the technical superiority of the United States in aviation and especially in the large-scale production of atomic weapons, which is likely to persist for many years after Russia begins to make them. It has to be admitted, however, that no attack by atomic weapons which we can envisage at present would alone prevent the Red Army from advancing to the Pyrenees, putting the industry of Europe to work for them and attacking Great Britain from Calais with long-range weapons. If defence through a strategic air force is to be the policy of the west, it is on its threat that Europe must rely; if the threat fails, Europe, and probably Great Britain too, are faced with such devastation that the hope of eventual American liberation offers little compensation.

Those who demand an alliance based on strategic bombing with atomic weapons have to ask themselves this question: is it likely that an alliance can quickly acquire such power that its threat will never be used, and that a *pax Americana* will give the world that period of peace which it so badly needs? Or is it equally likely that under the mounting threat of atomic bombing the Russian pressure to expand their sphere of influence will be increased to a point where it will precipitate the armed conflict which we hope to avoid?

# WESTERN CONTROL MEANS EASTERN SUPREMACY

By PROFESSOR M. L. OLIPHANT, F.R.S.

SCIENTISTS who took part in the war-time development of atomic energy gave earnest thought to the moral and practical problems which would arise if their efforts were successful. When it became clear that a weapon of unprecedented power would be produced discussion of these problems was intensified. It was thought that the new weapon had such unique and terrifying properties that its control would provide a test case of the possibility of international agreement, for it should be possible to discuss this material problem in an atmosphere free from the inevitable differences which arise over most other questions which so often involve nationality, economics, creed or language. Dr. Robert Oppenheimer, who led the team which produced the bomb itself, was appointed a member of the committee set up under Lilienthal to make proposals, and he was able to incorporate, in the control scheme formulated, much of the substance of the discussions among his fellow scientists. The official policy of the United States, embodied in the Baruch proposals, was naturally more rigid politically than the Lilienthal recommendations, but retained the generosity and grandeur of the original scheme.

The high hopes of the scientists were shattered in the earliest days of the deliberations of the Atomic Energy Commission. Before the end of the first month of operation of this clumsy body, where there was no discussion, no spontaneity, but only political speech, the scientific advisers present knew that they had failed.

It was right to make the experiment. If the case could have been argued dispassionately around the table, some agreed scheme might have emerged. It was equally right to abandon discussion when deadlock on vital principles rendered continuation abortive. Atomic energy has become just one more factor emphasising the political cleavage between West and East. In retrospect, it is clear that if an atmosphere had been provided in which agreement on the U.S. proposals was possible, the need for such a system of control would have disappeared. Atomic energy is now where it belonged from the beginning as part of the problem of peace and war, of the relationship between the peoples of the world.

The essence of the system of control advocated by the United States and agreed by the Western Powers, at any rate in principle, is that it must be world-wide. Adoption of the Baruch proposals by nations other than Russia and her satellites could give no security whatever. Indeed, inflexibility of the organisation needed would inevitably retard development of atomic energy in the western world, for peaceful as for warlike purposes. It would do little good to lose supremacy in this field to the more easily integrated eastern powers. It is doubtful, too, whether, when the time came to translate these idealistic concepts of a control scheme into action, countries such as Belgium, which enjoy a virtual monopoly of uranium supplies, would be any more ready to see them spread thinly and fairly over the globe than are those countries which possess oil! In fact, the question of the workability of a scheme of such close collaboration depends upon the feasibility of internationalisation on a scale which would render war and nationalism alike unthinkable.

I am convinced that control of atomic energy can be achieved only by so great a degree of political unification of the world that control is virtually a domestic problem. We must work for this unity—not for nice clean wars without weapons of mass destruction, but for the elimination of war itself. I believe that the basic principles of the loose association which has evolved in the British Commonwealth of Nations provide the key for this wider union.

## USELESS TO PRESS FOR CONTROL NOW—*A.S.A. COUNCIL*

IN a statement released last month the Council of the British Atomic Scientists' Association declares that no good purpose will be served by pressing for international control of atomic energy now, though it records its continuing belief in some form of international control as the most desirable ultimate solution of atomic weapons.

The Council does not believe a moratorium on atomic energy development offers any hope of easing the problem.

The statement continues: "Another suggestion that has been made is that a control scheme should be set up, which did not include all nations, but to which all nations willing to do so could belong. We believe that this proposal misses the point of the original plans for international control. These were designed to promote agreement and remove suspicion between nations which might otherwise be hostile. One important feature of the control schemes was that once a system of safeguards had been set up, there would no longer be any need for secrecy in scientific and technical matters, and this would make an important contribution towards removing mutual suspicion. It is certain that in a scheme which did not include at least all major powers secrecy would be retained. Schemes for closer collaboration between some nations, for example between Western Europe and the United States, might, of course, be desirable because of their advantages in the economic and military spheres, but they should not be regarded as a step towards the international control of atomic weapons."

The A.S.A. Council sees no hope of any early agreement over the atomic bomb and other weapons of mass destruction, and expresses the view that the solution can now be sought only through the constant promotion of all measures designed to make war less likely, and to reach a settlement between East and West.

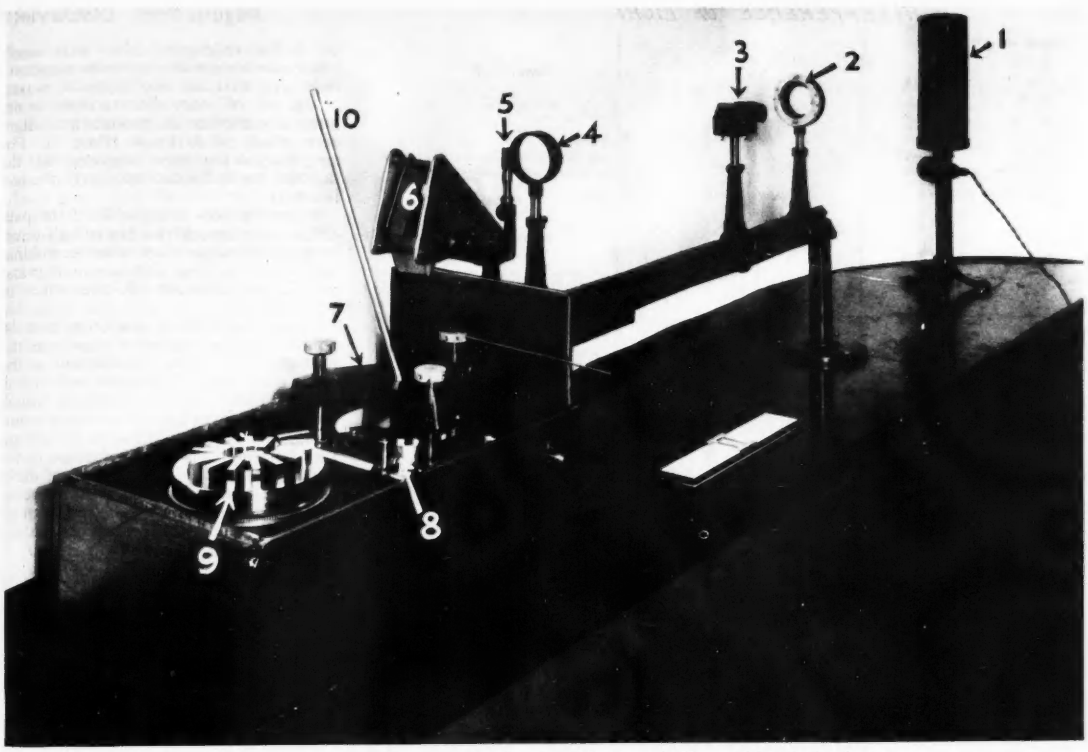



FIG. 1.—*Interferometer used for measuring length standards at the National Physical Laboratory.* 1. Cadmium lamp. 2. Condensing lens. 3. Illuminating and viewing unit. 4. Collimating lens giving parallel beam of light. 5. Micrometer control for prism. 6. Constant-deviation prism. 7. Tripod support for proof plane. 8. Base plate, with gauges wrung on ready for measurement. 9. Second base plate with gauges which can be substituted for 8. 10. Thermometer.

# Wave-Lengths instead of Yards

## LIGHT WAVES AS UNITS OF LINEAR MEASUREMENT

H. BARRELL, B.Sc., A.R.C.Sc., D.I.C.

EXACTLY a century after Jacques Babinet, the French natural philosopher, had propounded the idea of using wave-lengths of light as natural and invariable units of length, the first step was taken towards recognition of an ultimate standard of length. At their meeting in Paris in 1927, the Seventh General Conference of Weights and Measures agreed to the following provisional relationship between the International Metre and wave-lengths of red light emitted from a discharge lamp containing cadmium vapour:

1 Metre = 1,553,164·13 wave-lengths.

The significance of this relationship quoted by the international authority governing the metric system was qualified because the Metre remained the final arbiter on length measurements in that system. Only as an *alternative* to direct reference to the Metre or its national copies could measurements of length be made in terms of light waves; the number on the right hand side of the equation could be modified if at any time it was considered desirable to do so. Nevertheless this step was important, for it was founded on the belief that measurements of length would eventually be based on natural wave-length units rather than on material standards which are potentially liable to secular change, damage and destruction.

Many of the more precise length measurements of today are made in terms of light waves. All optical measurements of wave-lengths are accomplished in effect by comparison with the wave-length of the cadmium red line. The Metre has been measured on nine occasions during the past 55 years in wave-lengths of the cadmium red light, and the Yard twice since 1931. Reference length standards used in precision engineering are measured in terms of light waves to an accuracy of one-millionth of an inch.

The question may well be asked why those responsible for maintenance of the standards of length have refrained from superseding the existing material standards. Fundamentally, the answer is because no naturally occurring element, cadmium included, is known to emit waves of light which are entirely free from certain imperfections. But better knowledge of atomic structures enabled a prediction to be made many years ago that if atoms with a particular type of structure could be isolated or prepared from those found in nature, the main reason for the imperfections would disappear.

Techniques developed in connexion with the atomic bomb project can be used to manufacture one particular kind of atomic substance having the structure required to produce ideal light waves. By subjecting gold to irradiation with neutrons in an atomic pile, one isotope of mercury is obtained—an inversion of the ancient alchemist's dream. This mercury isotope $Hg^{198}$ has already been shown in the United States of America to emit light

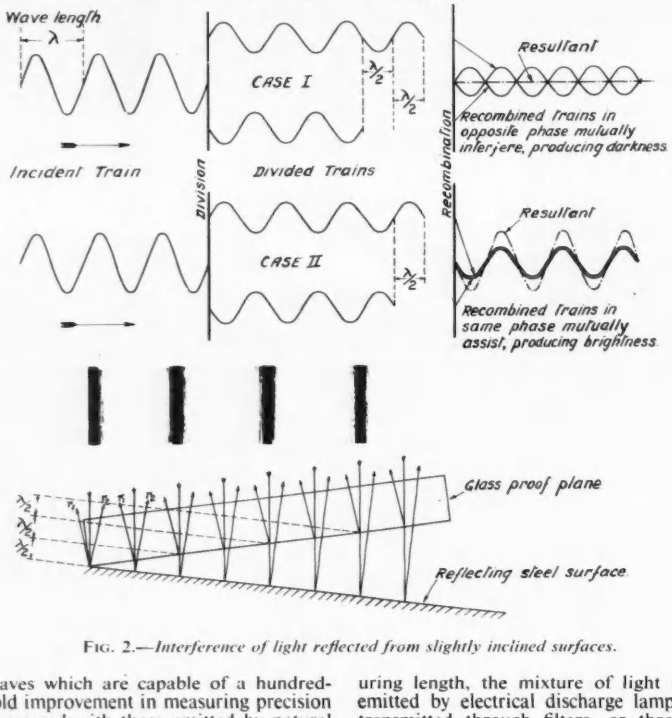



FIG. 2.—*Interference of light reflected from slightly inclined surfaces.*

waves which are capable of a hundred-fold improvement in measuring precision compared with those emitted by natural mercury and are also far superior to the best emitted by any natural element. Much work remains to be done before lamps containing $Hg^{198}$ become generally available to standards and industrial laboratories. There is no doubt, however, that we shall eventually adopt an ultimate standard of length defined by the wave-length of light, and most probably this standard will be the wave-length of green light from the artificially produced mercury isotope $Hg^{198}$.

### Using Light Waves to measure Length

The possibility of using light to measure length became appreciated during the development, in the nineteenth century, of the theory that light had a wave-like structure. Interactions between light waves were proved to be the origin of the striking optical effects described as interference fringes, or bands, and it was soon realised that these could be applied to the practical measurement of length. Eventually, it was demonstrated that light was part of a comprehensive spectrum of electro-magnetic waves ranging from the longest radio waves, through the radar, infra-red, visible, ultra-violet and X-ray regions, down to the extremely short cosmic rays.

Waves of light vary in length according to the colour. Red light consists of waves nearly double the length of waves of violet light: waves of an intermediate length of about one fifty-thousandth of an inch produce the visual sensation which we attribute to green light. Light consisting of waves of identical length is described as monochromatic. For measuring length, the mixture of light rays emitted by electrical discharge lamps is transmitted through filters, or through optical instruments known as monochromators, to isolate a particular colour or wave-length.

Interference fringes are observed if a beam of monochromatic light is first divided into two parts which are then recombined after the parts have been caused to travel paths of different length. The diagram at the foot of Fig. 2 represents a sectional view of a simple apparatus in which interference fringes are produced in this manner when a beam of *parallel* monochromatic rays, directed vertically downwards, illuminates the glass proof plane.* The rays entering the glass are divided at its lower surface into two parts. One part $r_1$ is reflected upwards, the other part $r_2$ is transmitted downwards, then reflected at the steel surface and subsequently transmitted upwards by the glass. It will be noted that the proof plane rests on the steel surface at one end so that a thin wedge of air is included. For clarity the angle is drawn much greater than is actually necessary in practice.

When an incident beam is divided at a boundary between the two media glass and air, in the manner shown in Fig. 2, the wave trains of the reflected and transmitted parts are automatically put out of step with one another. This effect is illustrated in the two uppermost diagrams of Fig. 2. If the difference in the length of path travelled by each part before recombination is zero or an even number of half-wave-lengths (the wave-length $\lambda$ is the distance indicated on the diagram), it is seen that the two trains of waves, being out of step after recombination, annul one another and produce a resultant zero effect of darkness (Case I). For simplicity it has been supposed that the incident ray is divided into parts of equal intensity.

Referring now to Case II, if the path difference is an odd number of half-wave-lengths the two parts are, after recombination, exactly in step with one another and produce a resultant additive effect of brightness.

These two limiting cases may now be applied to the apparatus shown at the foot of Fig. 2. The ray incident at the point of contact of the glass and steel is divided into two parts between which there is no path difference, and the circumstances are similar to those shown in Case I. When the parts are recombined in the eye of an observer, a condition of darkness is seen at that point. A similar condition is viewed in rays reflected from all points where the difference between the paths traversed by the rays $r_2$ and $r_1$ is equal to an even multiple of $\frac{\lambda}{2}$. Note also that the difference of path is twice the thickness of the air film between the glass and steel surfaces at the points considered. If twice the thickness of the air film is an odd multiple of $\frac{\lambda}{2}$ a condition of brightness is observed, as in Case II.

The simple apparatus of Fig. 2 is described as an interferometer. The image seen in light reflected from it is crossed by a series of dark bands or interference fringes, as shown in plan view above the sectional drawing. These fringes are straight and parallel to the intersection line of the surfaces if the surfaces are truly flat. Any particular fringe is a locus of constant thickness of the air film between the surfaces, and serves the same purpose as a contour line on a map. Changes in the inclination of the glass plate or of the colour, and therefore the wave-length, of the illuminating beam produce changes in the separation of the

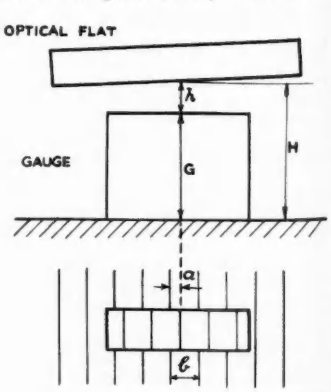



FIG. 3.—*Method of measuring a length standard in terms of light waves.*

* A proof plane or optical flat are terms applied to accurately worked plates of glass or quartz which have surfaces flat within a few millionths of an inch.

fringes. The separation of adjacent dark fringes represents a change of one-half wave-length in the distance between the surfaces and corresponds to a step of about one-hundred-thousandth of an inch for green light. Any departures from straightness or alignment of the fringes due to errors in flatness of the surfaces can easily be detected even if they are smaller than one-tenth of the fringe separation; surface errors of one-millionth of an inch are therefore clearly displayed.

The thickness of the air film at any particular point can also be directly measured in terms of half-wave-lengths by counting the whole number and fraction of fringe spaces between the place of contact, where the zero fringe is situated, to the point concerned. If the range of thickness were larger than represented in Fig. 2, direct counting of fringes would become wearisome to the eye and liable to error. Other methods are therefore employed to evaluate practical lengths from the observations of interference fringes.

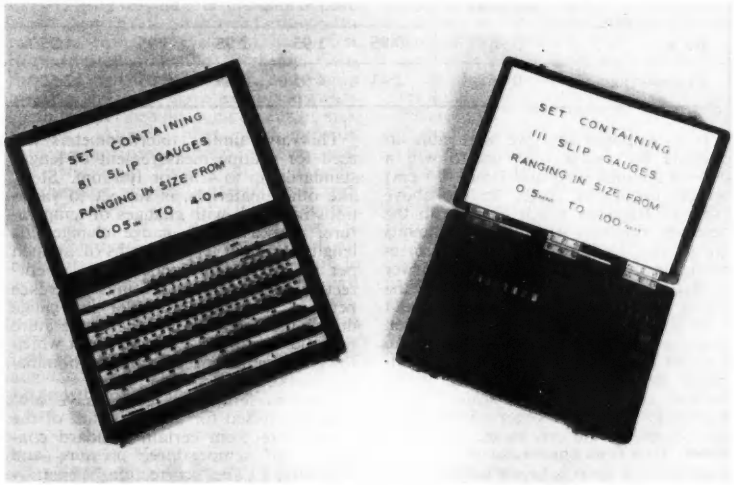



FIG. 4.—*Sets of precision engineers' length standards.*

## Practical Measurement of Length Standards

The most convenient form of length standard for measurement in light waves is the end-standard. With this, length is represented by the distance between two flat and parallel end-surfaces, and crude examples of it served as legal yard standards from the reign of Henry VII until 1824. The modern end-standard, introduced by the Swedish armament engineer, C. E. Johansson, about 50 years ago, consists of a steel block or bar with flat, parallel and hardened ends which are highly finished. Sets are manufactured containing convenient series of sizes ranging from 0·05 in. to 4 in. or from 0·5 mm to 100 mm, and in this form are generally called slip or block gauges. Sets containing longer gauges up to a yard or a metre in length are also available. Two typical British-made sets of slip gauges are illustrated in Fig. 4, one of inch and the other of millimetre sizes.

An interesting feature of these modern end-standards is that two or more can be 'wrung' together, or brought into close contact with other flat surfaces, to form additive combinations which are strongly adherent owing to the action of molecular forces of cohesion. At the National Physical Laboratory the separation of two surfaces in wringing contact has been measured and found to be about one-fifth of one-millionth of an inch. For all practical purposes, therefore, the length of a wrung combination of gauges is equal to the sum of the individual sizes.

It is the wringing property which renders end-standards so convenient and practical in service, for it enables the precision engineer to form combination standards of any desired length within the capacity of the series of sizes provided by the makers. The same property and the high optical quality of the mirror-like ends are utilised in standards laboratories for measurements in terms of light waves.

Referring now to the diagram in the upper part of Fig. 3, representing a sectional view of the essential components of an interferometer for measuring end-standards, the gauge is shown with one end wrung to another flat steel surface, indicated by the line with cross-hatching underneath. The glass optical flat, or proof plane, is supported above the upper end of the gauge so that it is slightly inclined to the parallel surfaces of the gauge and base.

If the interferometer is illuminated by parallel rays of monochromatic light directed vertically downwards, two sets of dark interference fringes will be seen, as depicted underneath the sectional drawing. One set is superposed over the gauge, and the other set, parallel to the first, over the projecting steel base. Each arises from interference between beams which are produced by division at the lower glass surface. The inner set is due to light reflected from the glass and from the gauge, and the outer to light reflected from the glass and from the base.

Let the separations of the glass from the gauge and from the base at the centre-line of the gauge be $h$ and $H$ respectively. If $h$ and $H$ could be individually evaluated by counting the whole number and fraction of fringe spaces from the intersection of the surfaces, as in Fig. 2, the length $G$ of the gauge at its centre would be obtained in half-wave-lengths by subtracting $h$ from $H$. This cannot be done because the surfaces do not intersect and the fringes cannot be numbered.

The difficulty is overcome in the following manner. By adjusting the inclination of the glass, a dark fringe on the gauge can be brought into approximate coincidence with the centre-line. It is now known that the vertical distance of the glass above the gauge centre must be a whole number of half-wave-lengths. Unless the gauge length happens also to be a whole number of half-wave-lengths, there will be a displacement between the inner and outer sets of fringes. The value of this displacement is obtained by estimating the amount $a$ by which the fringe at the gauge centre is in advance of the adjacent base fringe on its left and expressing it as a fraction of the fringe space $b$. The sense in which the fraction is estimated is clearly from left to right in Fig. 3, because the ends of the inclined surfaces are nearer together on the left. The gauge length is therefore equal to some unknown whole number of half-wave-lengths plus a known fraction $a/b$. If the two sets of fringes are exactly in line, the fraction is zero.

The same estimations are then made in, say, three other different colours or wave-lengths of light well distributed in the spectrum. If cadmium light is used, the red, green, blue and violet rays serve admirably for this purpose. In general the fractions change from colour to colour.

An ingenious method, originated by a famous French metrologist, J. R. Benoît, is now employed to evaluate the gauge length from the fractional results. This method of exact fractions (or coincidences), as it is described, is best explained by reference to the following simple example. Suppose we know that, to the nearest $\frac{1}{8}$ in., the distance between the ends of an object is about 5 in. We then measure its length more exactly by means of an ordinary ruler on which the numbering of the divisions has been obscured and which is differently divided on its two edges—one edge in inches and tenths and the other in centimetres and tenths (millimetres). In turn we put the zero mark for each edge of the ruler in coincidence with one end of the object and read off the excess fraction of a unit coinciding with the other end. Suppose we find that the excess fractions on the inch and centimetre scales are 0·95 and 0·55 respectively.

As we know that 1 in. = 2·54 cm, we can build up the following table of possible answers for the length of the object:

| *Scale* | *Observed fractions* | *Possible values of length assuming 1 inch = 2·54 cm* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| INCH | 0·95 | 0·95 | 1·95 | 2·95 | 3·95 | 4·95 | 5·95 | 6·95 | 7·95 | 8·95 etc. |
| CENTIMETRE | 0·55 | 2·41 | 4·95 | 7·49 | 10·03 | 12·57 | 15·11 | 17·65 | 20·19 | 22·73 etc. |

It is supposed that we were able to estimate the excess fractions to within 0·05 on the inch scale and 1 mm (0·1 cm) on the centimetre scale. In the above table all fractions which agree with the observed fractions within these amounts are printed in heavy type in the corresponding rows. The most probable answer is that the length is 4·95 in. because the object was already known to be about 5 in. long. The value of 4·95 in. when converted becomes 12·57 cm; as the fraction actually measured on the centimetre scale was 0·55 and the whole number of units on this scale is now known to be 12, the observed length of the object on the centimetre scale was 12·55. Thus from knowledge of the excess fractions, the ratio between the two scale units and the rough length of the object we have derived an accurate value of the length in terms of both units.

If no information on the length of the object were available it would be difficult to decide which of the three alternative answers was correct from measurements on two scales only, and there are other possible 'coincidences' to be found if the table is extended. But further fractional measurements can be made with scales divided in terms of other units with known ratios and then the true length can be evaluated from a very rough preliminary knowledge of the length. The more scales that are used the less likely it is that a coincidence between all the observed and calculated fractions can occur except at the true length.

For measurements in terms of light waves, the relative wave-lengths of the various monochromatic rays are known to extremely high precision. Manufacturers of the highest quality of precision engineers' gauges are able to adjust the lengths to an accuracy equivalent to one or two half-wave-lengths. As the excess fractions are measured to an accuracy of one-tenth of the fringe spaces or better, gauge lengths can be evaluated by application of the exact fractions method to an accuracy equivalent to one-millionth of an inch without ambiguity.

A photograph of one of the gauge interferometers at the National Physical Laboratory is shown in Fig. 1. When using this instrument it is possible to prepare up to 20 gauges at a time for measurement in sequence by wringing them in a suitably spaced radial arrangement on a base plate of steel. The base is capable of rotation under the support for the optical flat so that the gauges can be rapidly measured in sequence. Fig. 1 shows the cadmium lamp at the back, the illuminating and viewing units mounted on the optical bench, with the prism at its nearer end for analysing the cadmium light into its constituents. A base plate with gauges ready for measurement is seen in the foreground.

This and similar interferometers are used for routine measurement of length standards up to 4 in. or 100 mm. Steel, like other materials, is subject to variations in length with changes of temperature, and a 1-inch gauge changes its length by about 11-millionths of an inch per 1°C change in temperature. A correction is applied for any difference between the temperature of the gauge during measurement and the temperature of adjustment (20°C or 68°F) at which the gauge actually represents the nominal size marked on it.

The interferometer results have also to be corrected for any variation of the atmosphere from certain standard conditions of temperature, pressure and humidity. The correction generally amounts to less than 1 part in a million and could be eliminated by measuring in an atmosphere of constant density or in a vacuum. It arises because the refractive index of air, as of other transparent substances, varies with density. In order to eliminate the effects of refractive index, the more recent measurements of the yard and the metre in wave-lengths have been made either in a vacuum or in air for which the refractive index was also measured. The results were then expressible in terms of the more fundamental unit of a wave-length in vacuum, which is a naturally reproducible constant.

### The Metre and the Yard in Wave-lengths

The methods by which the Metre and the Yard have been measured in terms of light waves are developments of the simple processes already described for evaluating length. Since 1892, the Metre has been measured on nine occasions in wave-lengths of red light from a cadmium discharge lamp. In relation to the wave-length of light the International Metre, deposited in a vault of the International Bureau of Weights and Measures at Sèvres, France, has been constant in length during this period within the experimental accuracy of measurement, corresponding to rather less than a half-wave-length of the red light.

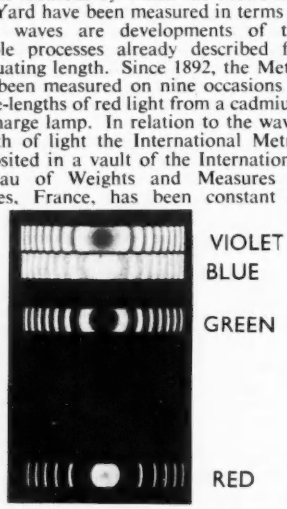



FIG. 5.—*Interference fringes showing the complex nature of the green, blue and violet rays of cadmium in contrast to the red rays.*

At the N.P.L. the Yard, as well as the British national copy of the Metre, have been measured in terms of the same light waves, not only in air but also in a vacuum. The values in terms of cadmium red waves *in a vacuum* were:

1 Metre = 1,552,734·44 wave-lengths.
1 Yard = 1,419,818·24 wave-lengths.

If, through some catastrophic event, the International Prototype Metre and the Imperial Standard Yard, with their copies, were damaged, lost or destroyed, the metre and yard units could be reproduced with very high accuracy from these figures.

### Measurement of longer distances

There is a natural limit to the distance which can be directly measured by means of a train of light waves. The prime reason for this arises from the discontinuous nature of radiation. The maximum length which can be directly measured in light waves is about 10 in. (25 cm). Using rays from a krypton discharge lamp cooled in liquid air, it is possible to measure 20 in. in one operation with the aid of a special type of interferometer which automatically adds two directly measured lengths.

Greater distances are measured either by successive additions of directly measured lengths, much as with a measuring rod, or by means of a series of optical multiplying processes. The latter method has been applied in Finland and Japan to measure distances up to 200 metres and to calibrate standards for geodetic measurements of length.

During recent years the interferometric technique has been employed in Germany in attempts to measure the frequencies of centimetric and millimetric radio waves such as are used in radar. The accuracy attained was only of the order of 1 part in 10,000. If electronic oscillators could be continuously controlled to produce radiation of accurately known frequency (or wave-length), there is a possibility of applying waves of much greater length than the visible atomic radiations to the measurement of long bases. The radiated trains would not be limited in length because they are not subject to the quantum restriction of atomic radiations.

### The ultimate standard

The red light from a cadmium lamp serves as the present standard for measurements of all other optical wave-lengths and, provisionally, as an alternative to the metre for other types of length measurement. But naturally occurring cadmium consists of a mixture of several

different isotopes which cannot readily be separated from one another by chemical or other means. The defects of light radiated from natural cadmium are well illustrated in Fig. 5, which shows interference fringes in four intense monochromatic rays—red, green, blue and violet —emitted by cadmium in the visible spectrum. Each image displays a broad diametrical section of a system of bright concentric rings on a dark background. The green, blue and violet systems are seen to be complex compared with the red, which appears to be ideally simple. Atomic physicists are able to state that ideal monochromatic radiation can only be obtained from a single isotope having a certain structure and that natural cadmium does not satisfy the specification. Some indirect evidence of complexity in the red ray has indeed been obtained.

The possibility of finding a more suitable radiation from a single isotope of the right type has recently been strikingly realised in the U.S.A. by the work of J. H. Wiens and of W. F. Meggers on the mercury isotope $Hg^{198}$. The practicability of extracting very minute amounts of pure $Hg^{198}$ from gold, after irradiation with neutrons from a cyclotron, was first demonstrated in 1940 at Berkeley, California, although the first lamps containing artificial mercury have been somewhat ruefully described as reminiscent of sick fireflies. Atomic piles now provide extremely intense sources of neutrons, and the National Bureau of Standards, Washington, already has 60 milligrammes (about 1/500th oz.) of $Hg^{193}$ prepared from 40 oz. of gold; this quantity is sufficient to make, perhaps, a dozen bright and durable lamps. Fortunately there is every hope that this modern alchemy will yield adequate quantities of artificial mercury, not only in the U.S.A., but also in this country.

If this hope is realised, the ultimate standard of length will most probably be constituted by the wave-length of the green ray from isotopic mercury. The metre and yard units of length would then be defined in terms of this wave-length in a vacuum, and advantage could be taken of the opportunity to fix the definition of the yard so that:

1 yard = 0·9144 metre (or 1 in. = 25·4 millimetres exactly).

This would differ from the existing legal relationship in this country by slightly less than 1 part in 1 million.

In the near future it will be possible to reproduce, by optical means and through the agency of end-standards, either unit of length, together with the corresponding fractions and multiples, to an accuracy of 1 part in 100 millions for the unit. This precision would be available at any time, in any place and to any organisation or persons provided with the appropriate discharge lamp and the accessory measuring equipment.

(This review, containing references to part of the research programme of the National Physical Laboratory, is published by permission of the Director.)

# Four Films About Children

A PLANNED series of films can be far more useful than a haphazard set made for various different audience groups, and our Ministry of Health deserve much credit for their series of films about children. It started with three films on 'How it works' about children's eyes, ears and teeth, giving parents simple lessons in physiology so that they could take the steps needed to keep those organs in good condition. The next three films, which were recently completed, move from the physiological field into the psychological. Their titles are *Your Children and You*, *Your Children's Meals* and *Your Children's Sleep*. This is very desirable because there is more unnecessary unhappiness due to faulty upbringing of children than there is from bad ears, eyes and teeth. On the other hand it is far easier to find out what steps should be taken to keep good ears, eyes and teeth than it is to find out the best ways to bring up children so that they are happy and eat and sleep well. Child psychology is a young study but those working in this field have already made observations which could be of the greatest value.

*Your Children and You* deals with some of the problems of bringing up children. The problems are the ordinary ones of the changes the baby's arrival makes in the household, feeding habits, cleanliness, jealousy, naughtiness, fears and so on. Some ways in which parents can 'without growing wings' avoid or deal with these troubles are discussed in a pleasant and uncondescending manner which is most acceptable. The photography is technically outstanding and the commentary skilfully done. The film starts with the unhappy implication that child raising is always a struggle for mastery between child and parent, there is no reference to any fun to be obtained and there is an unkind reproof to Granny in one sequence. However, it is such a well-made film that it is not surprising that it has been very popular though it really should not be shown without someone with knowledge of child psychology to comment on it and answer questions. There is never any difficulty in starting a discussion after this film.

*Your Children's Meals* show how a child's appetite goes when he is excited, tired and so on. Smaller helpings, playing a game or eating in company may help, but you must be firm and Father must pretend to like the food. Attractive-looking food and punctual meals are wisely stressed. It is surprising that when the importance of nice-looking food is emphasised, no mention is made of what is surely as important, encouraging a child to be discriminating as regards the taste and quality of the cooking. No child should be compelled to eat greens cooked as they are in this film. There is no vitamin C and no nourishment to be had from them, and yet we are urged to be 'firm' about the child eating them. The film is photographed with great skill and much imagination, but leaves an impression of being rather muddled.

*Your Children's Sleep* is a far more polished article. It starts from the idea that there is always a reason for a child failing to sleep. In the child, too, excitement or worry have more influence than in the grown-up because children react in an 'all-or-none' way to any mood. There is a memorable sequence of a day-dreaming boy and another of a girl whose very tidy mother sets too high a standard for her, so that the child wakes crying out in the night from her anxiety. The film ends by reviewing some of the steps parents can take to ensure good sound sleep for their children.

*Know Your Baby* is a Canadian film. Mrs. Phillips gets her two young children to help her prepare for her coming baby, so that their proprietorial feelings may swamp any jealousy when the baby arrives. The importance of breast feeding for the new arrival is hardly sufficiently emphasised but there is very good advice on how to do bottle feeding so that the child is not cheated of the affectionate contact which he needs as well as food. The fact that older children may regress to a baby-ish mode of behaviour is observed and advice on how to prevent it and to deal with it is given. Bathing and clothing are also shown. The film is in colour and in a very simple way is attractively photographed, though it fails to use the camera in the lively way it is used in the three British films. The film as a whole is a most acceptable film for conveying an attitude—namely that affection is just as important to the well-being of the child as is food or clothing.

Both *Know Your Baby* and *Your Children's Sleep* can be recommended as suitable to stand by themselves for lay audiences. For the other two films it is important that some informed person be there to correct some of the statements or implications. In the U.S.A. a film strip has been made to be shown with the film *Your Children and You*, and point out the controversial nature of some of its conclusions. The reason that *Your Children's Sleep* is so much better than the other two British films is because its style is less didactic and because to the excellent team which made the earlier films there was added for this one a first-class technical expert on the subject. This is a step of very great importance for the future well-being of scientific and propaganda films in general and of health education too.

R. MAC KEITH.

(*Know Your Baby* can be borrowed from the National Film Board of Canada, 8-9 Long Acre, London, W.C.2. The other three films are distributed by The Central Film Library, Imperial Institute, Exhibition Road, London, S.W.7.)

*This review is contributed by the Scientific Film Association, 34 Soho Square, London, W.1.*

# Far and Near

### Substitute for Petrol

AT a recent American Chemical Society meeting Professor L. F. Audrieth said that with the necessity of conserving coal and petrol supplies such substances as ammonia and hydrazine should be considered as alternative fuels. During the war the Germans experimented successfully with hydrazine as a power source for submarines. An expensive but excellent fuel, because it burns with a hot flame and gives off no toxic fumes, it has been used in rocket engines.

### Photo-finish Equipment at Olympic Games

FOR the first time at the Olympic Games equipment to give photographic records of the finish of all races is being used. This photo-finish equipment is provided and operated by the company who have used it for several years to record the finish of horse and dog races. (Readers interested in full details of the equipment should refer to *The Photographic Journal* for January 6, 1948.)

### The Threat of Famine

THE recent Sanderson-Wells lecture by Sir John Orr on 'Soil fertility—the wasting basis of human society' has been published by Pilot Press as a shilling pamphlet. The main theme is that the threat of famine represents the greatest challenge of the age.

### Operational Research in Lace-Making

THE Lace Federation Research Council, according to its second annual report, just published, is concentrating its efforts on operational research with the purpose of discovering the causes of stoppages of lace machines, investigating mending and mending methods, and acquiring quantitative knowledge as a starting point for future experimental research. This kind of research is considered most suitable for the present phase in the Research Council's history, when no proper laboratory facilities are available. The Council's research and liaison officer is John C. MacCallum, and his assistants now include V. C. Howard, R. S. Needham, F. K. Delves and D. Griggs.

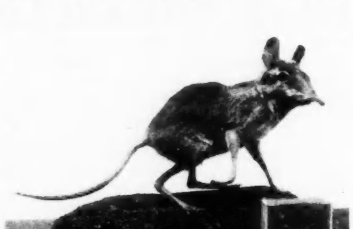
### International Locust Control

BRITAIN, Belgium, South Africa and Southern Rhodesia are establishing an International Red Locust Control Service, whose object will be the supervision and control of the Red Locust's breeding grounds—the Rukwa Valley in Tanganyika and the Mweru-Wantipa marshes in Northern Rhodesia.

### The Government and Scientific Policy

THE Advisory Council on Scientific Policy, set up to advise the Lord President of the Council, who is the nearest British equivalent to a Minister of Science, has published its first annual report (H.M. Stationery Office, Cmd. 7465, 6*d*). This 20-page document gives a summary of conclusions reached at the meetings which the Council held between March 1947 and May 1948. It transpires that the recent appointment of chief scientific officers at the Ministry of Food (Dr. Norman Wright) and the Home Office (Dr. E. T. Paris), followed the Council's recommendation that such officers should be installed to advise generally on the scientific aspects of departmental policy, and, in particular, to define the problems calling for research, to make the necessary arrangements for its conduct and to watch the application of its results.

The organisation of Governmental building research was considered, and the Council concluded that the D.S.I.R. should retain full responsibility here for research and initial development, whereas the Ministry of Works (which has been carrying out a good deal of research separately from the D.S.I.R.), should be responsible for reviewing the whole field of building research, identifying gaps and problems requiring further research, determining their relative priorities and



*An Elephant Shrew.*

bringing them to the notice of the D.S.I.R. or other appropriate research organisations; for keeping the technical development of the building industry under review, promoting the final stages of development, and encouraging the use by industry of the results of research.

During the year the Council nominated a Committee on Research and Productivity to report as to how science could increase national productivity. This committee produced an interim report of which the main point was that current fundamental research is unlikely, from its very nature, to have any short-term effect in increasing productivity, and for short-term results the more effective application of scientific knowledge already available is likely to prove much more fruitful. The committee advocated the use of operational research methods, and to bring this to the attention of industrialists an official book describing the achievements of operational research during and since the war is being prepared. (The authors, we understand, are Ritchie Calder and Maurice Goldsmith, and the book should be published early in 1949 by the Stationery Office).

### A Landmark in Malarial Research

LAST month the fiftieth anniversary of Sir Ronald Ross's discovery of the way malaria is transmitted was celebrated in London. The celebrations included an exhibition at the London School of Hygiene and Tropical Medicine, in which the Ross Institute for malarial research is incorporated.

### New Cyclotron for California

A CYCLOTRON eighteen times as powerful as the largest existing instrument is to be built on the campus of the University of California under Professor E. O. Lawrence's direction. The project will take three to five years and will cost $9 million. Professor Lawrence says the cyclotron will be designed to develop energies of 6000m. electron volts with protons, and perhaps 10,000m. with the use of alpha particles, whereas the 5000-ton existing cyclotron at Berkeley is only expected to develop energies up to 350m. electron volts, using protons. The new cyclotron will have a ring-shaped magnet requiring about 10,000 tons of steel, and it will have a radius of 55 ft. and an outside length of 140 ft.

### Malaria and Elephant Shrews

IT has been discovered that elephant shrews contract a form of malaria very similar to human malaria, and it is thought that they may prove better experimental animals for malarial research than chickens and monkeys. The discovery was made by the University of California's African Expedition led by Mr. Wendell Phillips.

### Stainless Steel Pioneer

THE death occurred on July 14, 1948, at the age of 77 of Mr. Harry Brearley, pioneer in the field of stainless steel production. It was in 1912 that he made a steel containing 12% of chromium, which he hoped would be ideal for rifle barrels. It proved quite useless for this purpose, but Brearley noticed it was remarkably rust-proof, and within a few years, cutlery made from this stainless steel came into use throughout the world. (Modern stainless steel differs from Brearley's, containing slightly more chromium) and a small percentage of nickel.

Brearley, in his autobiography, *Knotted String*, expressed his contempt for formal education (he himself left school at the age of 11), but believed in a broad vocational training leavened with wide cultural interests.

### Foreign Science Journals

ANY person may now import single postal copies of scientific and technical periodicals printed exclusively in a foreign language, the President of the Board of Trade informed the House on July 8.

Another recent parliamentary question dealt with bacteriological warfare, and the Minister of Defence stated that "the possibility that bacteria may be used in a future war is not being overlooked. Researches are being conducted so that we may be ready to meet any situation which may arise".

### Liquid Paraffin and Cancer

LIQUID PARAFFIN as ordinarily used is a harmless enough substance, but there is

some evidence to suggest that when it is 'cracked' by heating, cancer-producing substances are produced. The point is discussed in the *British Medical Journal* (June 12, p. 1141), which warned readers of the risks likely to arise from the widespread use of liquid paraffin in cooking.

### Unesco Secretariat in London

THE Secretariat of the British Committee and the national co-operating bodies for UNESCO has now moved to premises at 23, Belgrave Square, S.W.1. It will be known for convenience in future as 'The UNESCO National Commission'. The Secretariat, which remains part of the Ministry of Education, will be glad to receive visitors interested in UNESCO's work and is ready to answer enquiries, to supply publications and to arrange for speakers to attend meetings.

### An Institute of Biology?

THE formation of an institute for professional biologists, on the lines of those existing in other scientific professions, is being considered, and a memorandum on this proposal is available from Dr. J. F. Danielli, Chester Beatty Research Institute, Royal Cancer Hospital, London, S.W.3.

### When Hitler talked to Planck

MAX PLANCK, as head of the Kaiser-Wilhelm-Gesellschaft, visited Hitler in the spring of 1933, and as nothing of what took place on that occasion was allowed to be published the meeting became the starting point of many fantastic rumours, which might have become legends but for the recent publication in *Physikalische Blaetter* of Planck's own account of their conversation.

"When Hitler came to power, it was my duty, as the President of the Kaiser-Wilhelm-Gesellschaft, to pay a visit to the Fuehrer," wrote Planck. "I thought it was right for me to profit by this occasion for speaking on behalf of my Jewish colleague, Fritz Haber, without whose method for obtaining ammonia from the air the last war would have been lost from the very start. Hitler replied, 'Against the Jews as such I have nothing. But the Jews are all Communists, and these are my enemies. Against them my fight is directed.'

"I remarked that there were different kinds of Jews, some valuable to mankind, others without value, the first group including ancient families with the best German culture, and that one must discriminate. He replied: 'That is not correct: Jew is Jew; all Jews cling together like burrs. Therefore I must take action against all of them uniformly.' I remarked that it meant really self-mutilation if we compelled valuable Jews to emigrate, because their scientific work, which we needed urgently, would then benefit other countries. Of this he took no notice at all."

The interview ended when Hitler worked himself up into such a frenzy that, wrote Planck, "nothing was left but for me to remain silent and take my leave".

### Tank Culture of Mushrooms

THE large-scale culture of fungi in liquid media is now very familiar as a result of the quantity production of penicillin. When the method used for cultivating the mould that produces penicillin is tried for mushroom culture nothing recognisable as a mushroom results though a liquid culture medium proves capable of supporting life and growth of the spawn (mycelium), which increases rapidly in tanks containing juice expressed from asparagus butts and pear waste. An American scientist, Dr. H. Humfeld of the Western Regional Research Laboratory, U.S. Department of Agriculture, at Albany, California, has found, for example, that 20 grams of mycelium increased twenty-fold in 33 hours, and this mycelium is rather richer in protein and fat than ordinary mushrooms. A solution of glucose, sodium glutamate and inorganic salts has also proved a successful culture medium. Describing the results of his experiments in *Science* (1948, Vol. 107, p. 373), Dr. Humfeld says that the mycelium has the characteristic mushroom flavour and suggests this submerged-culture method might be applied not only in the manufacture of mushroom soups, gravies and flavourings, but also in the production of spawn for seeding mushroom beds.

### New Germination Seed Test

TRIPHENYLTETRAZOLIUM CHLORIDE is being used in the U.S.A. as a chemical reagent for testing the germination ability of many kinds of seeds. It is reported to be an exceedingly selective stain, being adsorbed by the live embryo but not by the rest of the seed. The vital sections of the embryo—plumule, primary root, etc. —can be easily distinguished after application, and sound prediction of germination capacity can be made. Commercial production as yet is limited and the material is being sold only for research investigations, but steady expansion is anticipated. If research experiences and claims for this stain can be reproduced in ordinary commercial practice the saving of time and labour in the seed industry will be substantial.

### South African Synthetic Petrol Plans

A HUGE synthetic fuel plant is planned for South Africa for erection near Vereeniging, reports *Chemistry and Industry*. 60 million gallons of petrol and 9 million gallons diesel oil are mentioned as its proposed output. (South Africa's yearly requirement for petrol is well in excess of 200 million gallons.)

The site contemplated is near power, water and cheap coal supplies and conveniently placed between the biggest markets—the Rand and the New Free State gold mines. It is believed that the process to be employed will be based on recent American developments of the Fischer-Tropsch process.

**JUNIOR SCIENCE**

No. 8 in the "Junior Science" series is unavoidably held over to the next issue.

### Photosensitive glass

A REVOLUTIONARY type of photosensitive material has been developed by the Corning Glass Works in the U.S.A. This is a glass which is sensitive to ultra-violet radiation, though no effect is produced until it is heated to 1000°F.; when exposed through a stencil or photographic negative, a print is thus produced in depth. The glass is originally perfectly clear and can be softened by heat, worked to any desired shape and suitably annealed. It can be handled by any form of artificial lighting but must be carefully protected from daylight or any other source of ultra-violet. A short exposure to such a source followed by about thirty minutes in a suitable oven produces an image in the glass. This can be in a variety of colours, depending upon the composition of the glass. The depth of the image depends upon the degree of exposure, the lighter portions being near the surface and the dark shadows deep in the glass.

Details of the mechanism of the process have not been published but the makers say that the image is produced by metallic substances held in solution in the glass, which are precipitated by the ultra-violet radiation as sub-microscopic particles and conglomerated by heat into particles of a size suitable for the production of an image. A number of different colours can be produced, depending upon the nature of the ingredients of the original melt. The shade and depth are decided by the ultra-violet exposure. By a suitable system of masking, different parts of the image can be printed in various tints. For example, one glass will give reds and purple, another blues, purples and reds, and another yellow and browns. The particles used to produce the image are extremely small, and very fine detail can therefore be recorded in the picture. The glass can be made in opalescent form as well as in clear, if desired.

So far the glass does not seem to have been put to much use. It is suggested for decorative glass-ware, imitation jewellery, church windows and architectural decoration, instrument dials and lantern slides. It is of particular interest to the photographic scientist as an example of a practical photographic printing process, employing a latent image, which nevertheless does not employ silver salts and which needs no treatment in liquid or gaseous developers or fixers.

A relevant article, which reviews the processes available for photographic reproduction on textiles, china and in glass has been published by *Mechanical Engineering* (1948, Vol. 70, p. 339).

### Corrections

THE barnacle at the top of the photograph on (p. 229, July issue) is *Balanus*, with six compartments.

May and Baker Ltd. have pointed out to us that the brand name of their anti-histamine compound is *Anthisan*, and not Antihisan (June issue, footnote on p. 168).

Throughout the note on trypanocidal drugs in our May issue (pp. 135–6) the word *phenanthridinium* was wrongly spelt.

# The Bookshelf

**On Understanding Science: An Historical Approach.** By James N. Conant. (Oxford University Press, London, 1947; pp. 146, 10*s.* 6*d.*)

THIS book is one of the most important contributions to the discussion on that very pressing problem. In a world in which science is one of the most dynamic forces, how can we bring to the layman a sufficient understanding of it to enable him to play properly his part as a democratic citizen? The key word is 'understanding'. "The remedy", says Dr. Conant, "does not lie in a greater dissemination of scientific information among non-scientists. Being well informed about science is not the same thing as understanding science. . . . What is needed are methods of imparting some knowledge of the Tactics and Strategy of Science to those who are not scientists."

Dr. Conant's 'tactics and strategy' means much more than 'scientific method' as it is usually expounded in text-books on that subject. It means the way in which science develops, or *is developed* by real human scientists, considered in its full concreteness. Hence he reaches quickly the conclusion that the required understanding must be imparted historically. Yet "the histories illustrating the Tactics and Strategy of Science are as yet unwritten". The book is not an attempt to write such a history. It is a discussion of how selected case histories could be presented to university classes of non-scientists (with a possible extension to adult education in general) in such a way as to bring the required understanding. And the statement of general principles is accompanied by the synopses of the sort of historical treatment Dr. Conant intends. One might quarrel with the emphasis in some of these historical illustrations, but the general outline of how history is to be used to promote the required understanding is most valuable and stimulating, and if the method is valuable it should not be difficult to correct the details.

S. LILLEY.

**Electro-Technology for National Certificate,** Vol. I. By H. Teasdale and E. C. Walton. (English Universities Press, London, 1948, pp. 325. 9*s.* 6*d.*)

THIS volume, the first of a series of three, is a recent addition to the Technical College Series published by the English Universities Press. It is excellently written, and the method of presentation of the subject matter indicates clearly that the authors have had many years' experience in teaching this subject. The treatment is thorough and the presentation logical, and teachers who have yet to gain experience in teaching this subject will find this book an excellent guide in the method of presenting the subject-matter.

The subject-matter dealt with is Direct Current Theory. The first chapter is a brief one entitled 'Preliminary Physical Science', in which the student is introduced to such units as the dyne, erg and calorie, with which he must familiarise himself in order to lead on to definitions and units of electrical quantities.

The book has been arranged in such a manner that a beginner in the subject can read it through without being burdened with mathematical treatments or advanced theory or explanations not considered essential for the understanding of the fundamental facts. Yet these sections are included for the benefit of the more advanced student. This has been achieved by relegating such theory or explanations to appendices at the end of certain chapters. Furthermore an addendum, containing proofs of various formulae involving a knowledge of the calculus, is provided at the end of the volume. Another useful section at the end of the book consists of ten tables containing data and information valuable to the electrical engineer.

The diagrams are clear and well drawn, and there are some excellent photographs illustrating electrical apparatus. Each chapter is terminated by a set of numerical exercises with answers appended. A commendable feature of these exercises is that many of them are so arranged that the student must search for the data required for their solution by referring to the tables at the end of the book. This practice will serve him well in training for the type of practical calculations he will have to make later on as an engineer.

The book can be thoroughly recommended to both students and teachers of Electricity.

**Flowering Earth.** By Donald Culross Peattie. (Phoenix House, London, 1948; pp. 200, 10*s.* 6*d.*)

THIS book is not just another book on botany. It is the poetic, romantic story of plants as seen by a keen botanist and nature lover. Based on 20 years' experience of plant collecting and examination, the book deals with all aspects of plant life, from theories as to the beginning of life to the rise of the modern floras. As a boy the author wanted to learn about plants so he left his job in New York and went into the country for some months studying nature at first hand. In his own words as he went into the fields he thought of the men and women in the towns "all holding jobs and grateful for them as a punished boy for supper thrust through the door". For months Peattie travelled about the American countryside collecting, identifying and drawing plants. Then he found he could go no farther without extra knowledge—so he went to Harvard and studied botany. Later he joined the U.S. Agricultural Service, but here, in the realm of the specialist, Peattie was not at home. The specialist he saw as a man "who may get all his facts to dance on the point of a needle"—and this was not for him. So he started on his travels again. After twenty years he puts on paper what he was taught and what he has learned, describing plant growth and life in words which prove he is as expert and knowledgeable in the use of language as in the art of science. This book, the result of two years' labour, although probably written principally for those who know no botany, will enthral everybody who reads it, whether botanist or neophyte.

**Partnership in Education.** (Jarrold, Norwich, 1948; pp. 158, 7*s.*)

THE initial difficulties of putting the 1944 Education Act into practice are now apparent. A re-distribution of powers and duties, and a definition of functions among the partners of the Education Service are some of these difficulties. In this education handbook the emphasis is laid on partnership, and the contributors raise problems of planning, administration and curriculum which must be faced if that partnership is to be made real and valuable.

The book is a series of eleven separate essays by fourteen well-known writers in the educational field. For this reason it is as difficult to review as it is to appreciate the pattern and development of education in this country at the present time. Perhaps it is the purpose of the book to help us to this appreciation and if so, it has achieved its object.

By way of introduction Mr. E. W. Woodhead deals with the general question of partnership in education and he is followed by Mr. C. Birchenough on the Ministry of Education; by Messrs. A. B. Clegg, F. Stephenson and J. Armitage on the Local Education Authorities; by Mr. Gordon Barry and Miss Helen Simpson on the Teaching Profession, and Mr. W. O. Lester-Smith on the Local Community.

These are partners indeed, and against the background of these able essays one wonders whether in the words of Lewis Mumford the ultimate result will be that "In time we shall create the institutions and the habits of life, the rituals, the laws, the arts, the morals that are essential to the development of the whole personality and the balanced community".

Adult Education and the Universities are dealt with at the end of the book by Messrs. D. E. Cooke and J. Mackay-Mure respectively, and one wishes that these subjects could have been included earlier in a position more suited to their great importance at the present time. Adult Education is surely among the great problems of our age.

Inspection, the Health Service, Industry and Commerce, and Design and the Environment of the Child are treated in a challenging manner by Messrs. R. H. Charles, W. A. Bullough, I. J. Pitman and Miss Helen Lowenthal.

As the latter says in her chapter "no writer . . . deals with the problem of design without waving an airy hand in the direction of education". The authors of this book have materialised the hand for us and have brought it heavily down on to our shoulders to arrest us so that we may consider this comprehensive survey of the problems besetting the partners in education. Altogether this book is well worth its price to the serious student of education.

CYRIL LLOYD.

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